ULY 1960
OLUME 3 • NUMBER 7

- Carter, Katzman, Reingold — The Use of an X-Band Solid-State Maser with a Conventional Duplexing System.
- Cuccia — Lightweight Integral-Package Traveling-Wave Tubes for Airborne Application.
- Glass — A Wideband Microwave Link for Telemetering.

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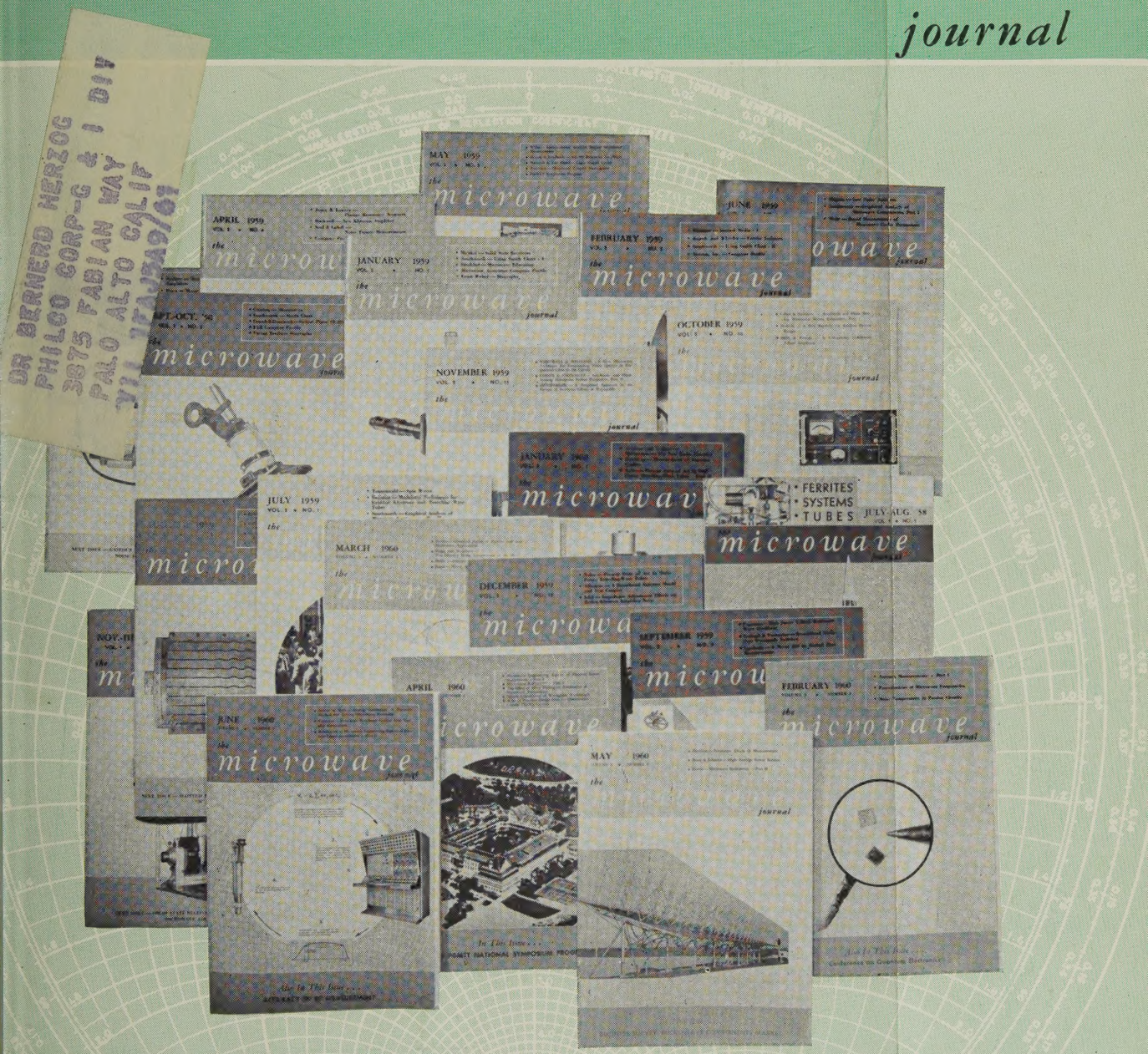
microwave journal



SECOND ANNIVERSARY ISSUE

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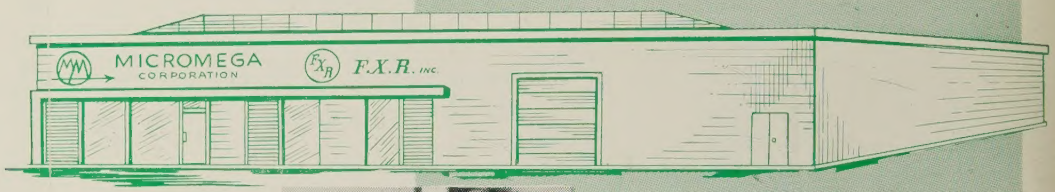

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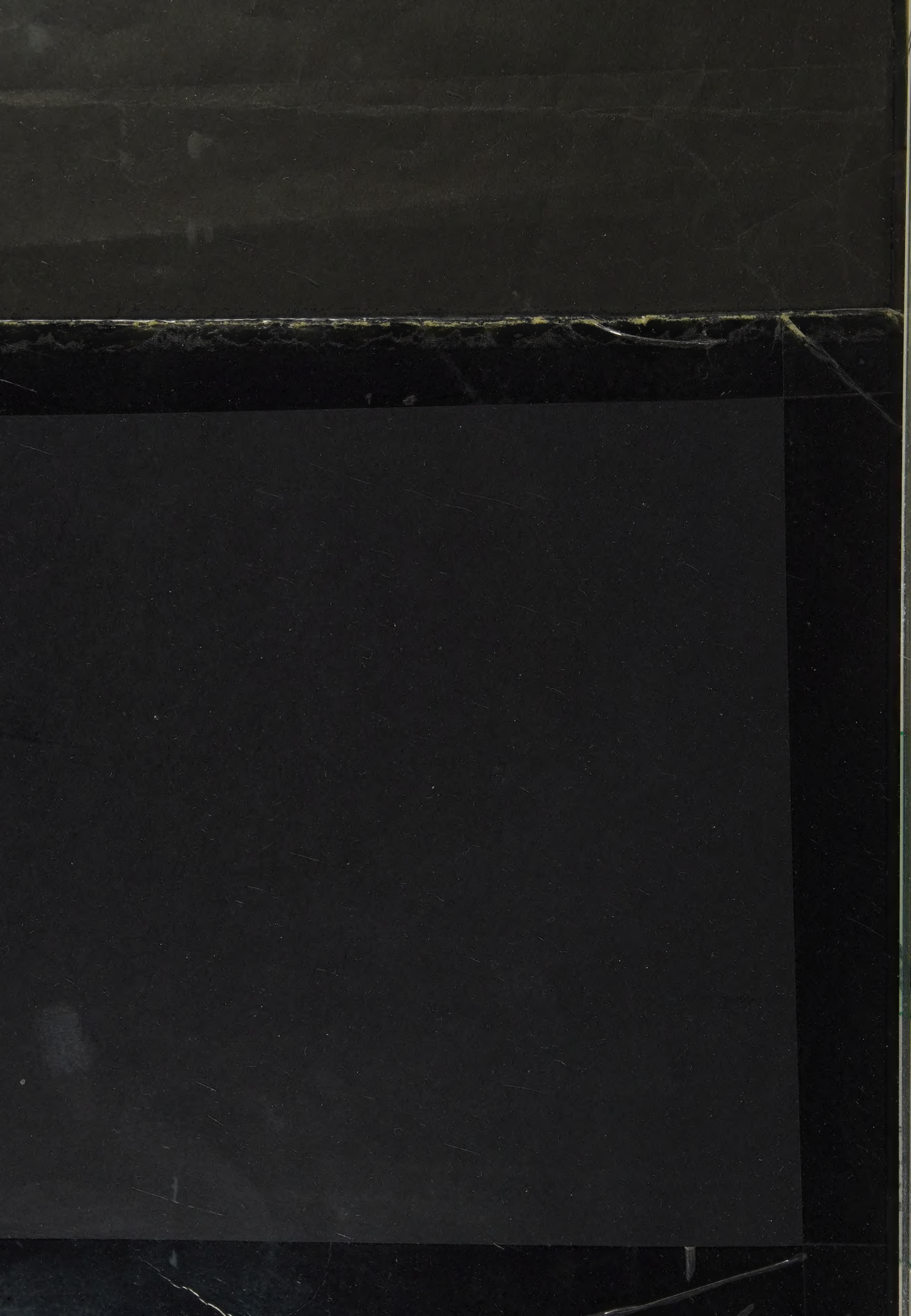

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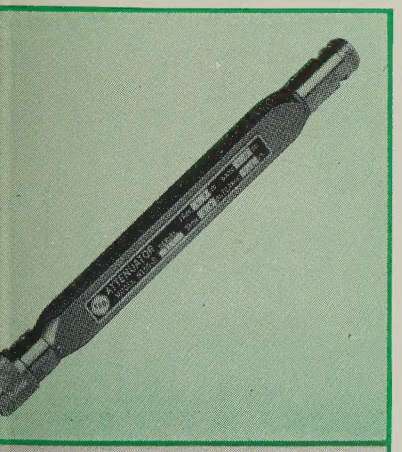

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(2 to 12.4 KMc for 20 db)
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Low VSWR and frequency sensitivity.
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- VSWR 1.1 max.
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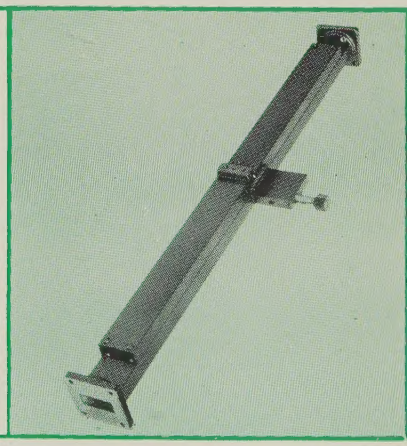

FIXED PRECISIO ATTENUATOR
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- Operation over full waveguide frequency ranges.
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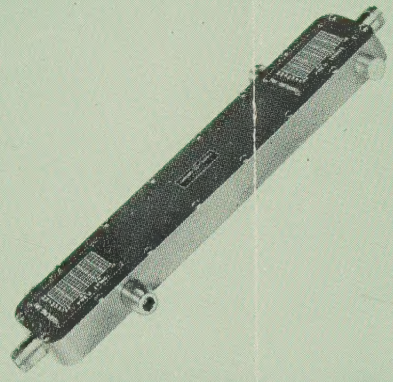

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- Crosstalk 60 db min.
- VSWR 1.10 max.
- Manual or solenoid operation.
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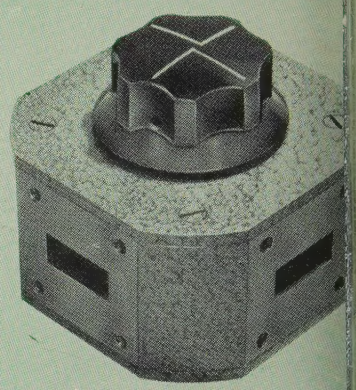

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Detecting The Invisible Half of Matter

An overwhelming percentage of space is a relative void, but drifting in that void are vast seas of rarified material, known as the interstellar medium. The amount of material in the interstellar medium is comparable with the total mass of the stars and is composed primarily of gas and dust. Giant radio telescopes, combined with the most sensitive radio devices ever constructed, are probing the interstellar medium. In this manner, radio astronomers seek answers for some of the most provocative questions posed by science.

Because interstellar space is so very cold, the major portions of the interstellar medium are optically invisible. For the most part, the presence of the medium can be detected only by radio astronomical techniques which are capable of measuring the minute amount of radio energy generated in space. Spectral line radiation from the interstellar medium is the most profitable area of study.

The gas which has been the main research objective is atomic hydrogen. A hyperfine transition in the ground state of the hydrogen atom occurs at a frequency of 1420.40572 $\pm$0.00001 Mc. Around the Milky Way, the hydrogen line appears in emission. In the direction of discrete sources (radio stars) the line is reversed and appears in absorption. Signal powers produced by this radiation at the terminals of an antenna are usually of the order of 10^{-18} watts; therefore, extremely high receiver sensitivities are required for research programs.

The study of this radiation is being vigorously pursued at the major astronomical observatories of the world. Objectives of the research programs include a measurement of the mass of the Milky Way, measuring the distance from the earth to the sun, determining distances to radio stars, mapping the spiral arms of the Milky Way, measuring the interstellar magnetic field, and measuring the gas content of island universes at very remote cosmic distances. A precise determination of a hydrogen line profile is critical for all these research programs. To accomplish this determination, a radiometric system must be extremely stable, ultra-sensitive, retain "flat" critical RF parameters while scanning, and operate reliably and dependably.

The development and manufacture of receiving systems meeting requirements such as those described above has been Ewen Knight's major activity for a decade. Ewen Knight radiometric systems are in daily operation at the leading radio astronomy laboratories in the Americas. Other systems, destined for giant radio telescopes now under construction in the United States, are now taking form at Ewen Knight. Similar receivers are being developed for missile trackers and radiometric navigation systems. Our staff, accustomed to "frontier" demands, stands ready to translate your most complex solid state or conventional microwave system requirements into reliable instrumentation.

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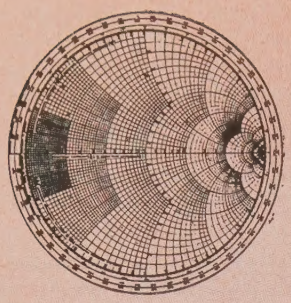

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Nomograms for Microwave Filters Design

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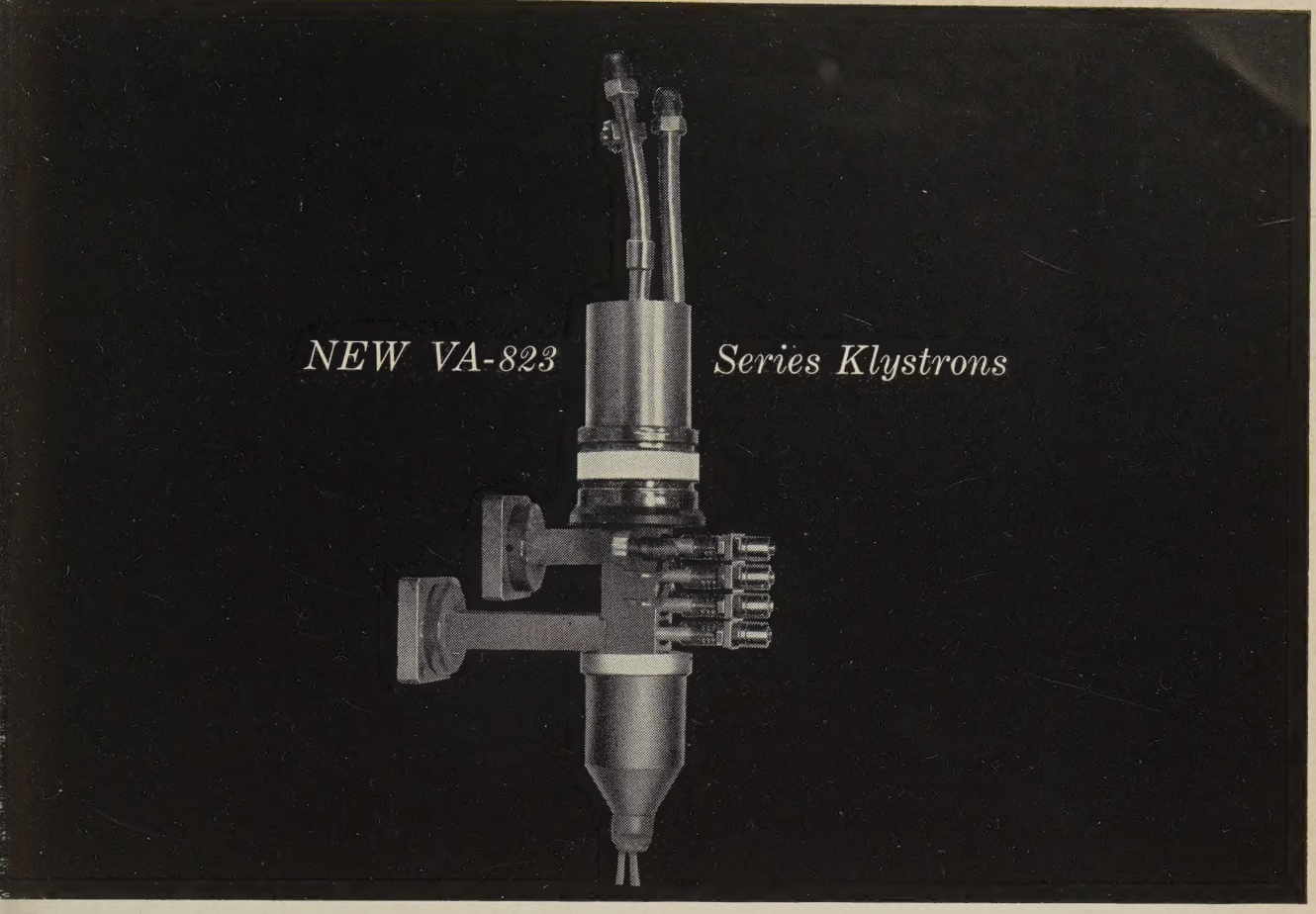

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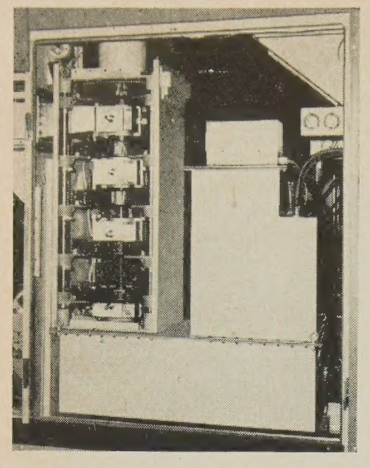

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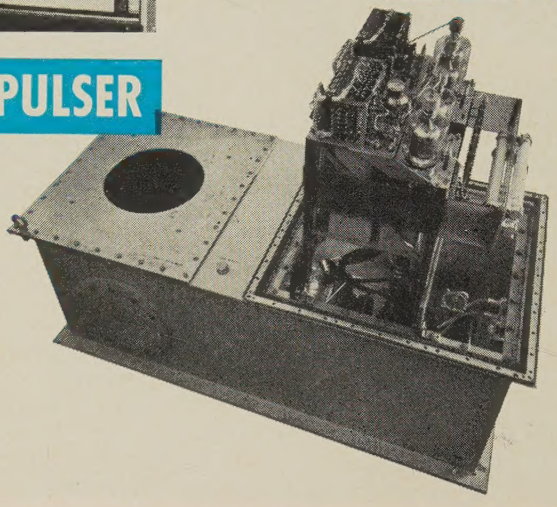
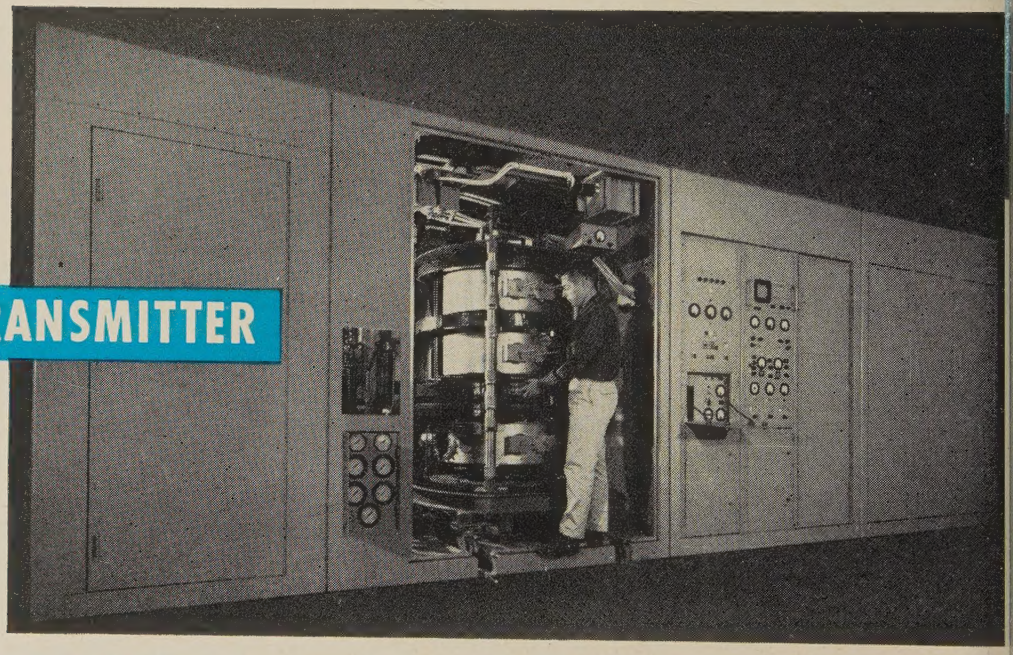


These photos indicate the degree to which our engineering and manufacturing groups feel at home with military specifications.

For Bendix Radio we are supplying 12 copies of a floating-deck modulator for AN/FPS 30 "Sentinel" Radar. For Motorola we are just completing a communication and control-system transmitter for the Sage program. We have also designed and built the modulator and power supply for the U.S. Marine Corps AN/MPS 21 Piggyback Radar System, under subcontract to Sperry; and the transmitter for the Azusa Radar, under subcontract to Convair.

MOTOROLA TRANSMITTER



You are invited to consider the possibilities of continuing your professional advancement with Levinthal Electronic Products. Your resume should be sent to the personnel manager, Bert Carpenter.

All these and more have been designed and built to full military specifications in the Levinthal plant. Your needs in this area can be met here too.

Why not call and discuss them with Bob Johnson, our applications engineering manager?

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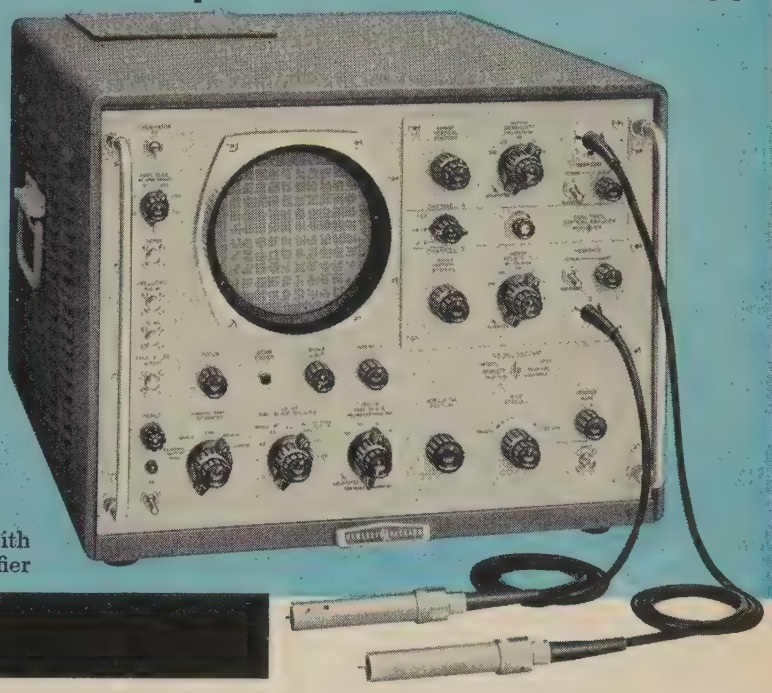
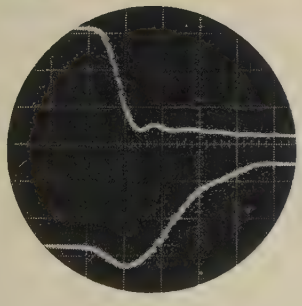
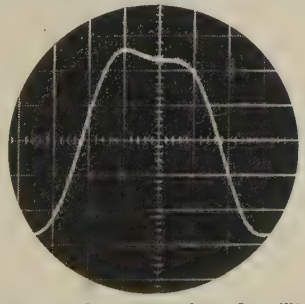


hp 185A Sampling Oscilloscope with
hp 187A Dual Trace Amplifier



Bright, clear dual pulse presentation on *-hp-* 185A's big 5″ scope face. Top trace shows pulse from mercury pulser applied to 2N1385 mesa transistor. Bottom trace shows responding turn-on of transistor. Dip in bottom trace at start of turn-on results from capacitance. Scope sweep speed is 1 mμsec/cm.



Brilliant, steady trace of a 2 millimicrosecond pulse on the 185A 5AQP cathode ray tube face. Sweep speed (time between vertical graticule lines) is 0.5 mμsec/cm.

IMPORTANT FEATURES: Less than 0.7 mμsec rise time. 500 MC pass band; bright steady traces even at rep rates down to 50 cps. Sensitivity 10 mv/cm to 200 mv/cm; vernier increases sensitivity to 3 mv/cm. Sweep times 10 mμsec/cm to 100 mμsec/cm with expander to 0.1 mμsec. Front panel delayed sync pulse for triggering circuits under test. Dual channel input. 10 cm vertical display. High sensitivity, wide dynamic range. 100,000 ohm probe minimizes circuit disturbance. X-Y recorder output. Time-amplitude calibrators, beam finder, panel similar to conventional scopes.

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MICROVIEWS

OF THE MONTH

43 ▶ **THE USE OF AN X-BAND SOLID-STATE RUBY MASER WITH A CONVENTIONAL DUPLEXING SYSTEM**

John L. Carter, Morris Katzman and Irving Reingold

A series of experiments were performed with an X-band, solid-state, three-level ruby maser and several conventional types of X-band duplexer tubes under conditions simulating actual radar systems application. Leakage levels for the onset of deterioration of maser performance and for saturation of the maser were determined. Measurements were also made of the recovery time of the maser after having been fully saturated. The results indicate the degree of improvement required of the duplexer, or the degree of protection that must be provided in addition to the duplexer, if optimum use is to be made of the gain characteristics of the three-level ruby maser.

47 ▶ **LIGHTWEIGHT VERY-WIDE-BAND INTEGRAL-PACKAGE TRAVELING-WAVE TUBES**

C. Louis Cuccia

This paper describes new techniques and tube components which have made traveling-wave tubes rugged, lightweight and small in size, suitable for use in airborne and missile systems. These techniques and tube components relate to three types of integrally packaged tubes, each using a different method of electron-beam focusing; viz., electrostatic focusing, periodic permanent-magnet focusing structures and miniaturized-solenoid focusing. Mechanical and electrical features of each of the three tube types are described in detail.

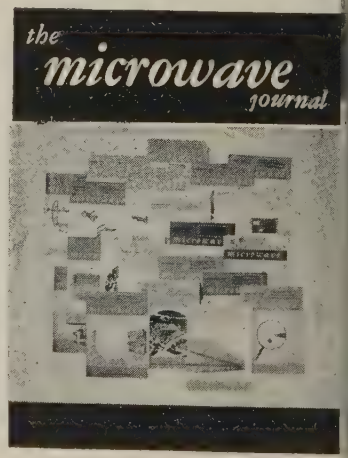
58 ▶ **A WIDE-BAND MICROWAVE LINK FOR TELEMETERING**

Raymond E. Glass

A telemetering system using a wide-band microwave link has been developed for measurement of pulse phenomena. This system measures pulse-risetime, pulse-duration, pulse-amplitude and pulse-interval very accurately. Pulsed-frequency modulation of a 4 kilomegacycle per second RF carrier is used for information transmission.

OUR COVER

This issue marks another milestone for us: two years ago the first *microwave journal* appeared. We reflect on the events of those two years with thanks to our associates, authors, advertisers, readers and all whose support encourages us to provide more and better *microwave journals* for the future.

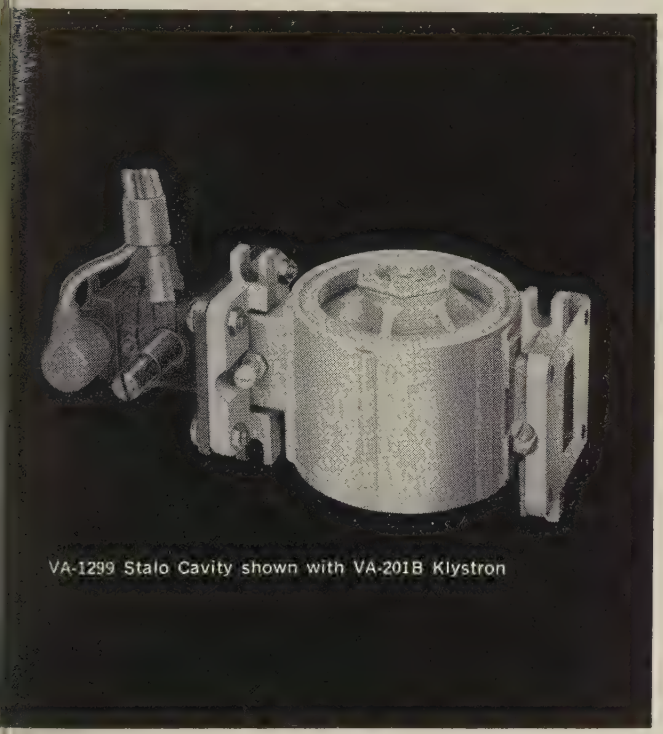


DO YOU KNOW THE SIMPLEST WAY TO STABILIZE MICROWAVE FREQUENCIES?

Short-term frequency stability as high as one part in 10^9, plus substantial noise reduction, can be achieved by a VARIAN STALO which is a combination of klystron local oscillator and stabilizing cavity. The stalo cavity is a hollow shell—highly refined.

By means of passive stabilization, this cavity in many applications accomplishes the same ends as either active AFC stabilization systems or crystal-plus-electronic-multiplier circuits. But the stalo cavity, because it is passive, has extreme reliability and an infinite life. Most of them require no troubleshooting or maintenance effort—ever—once they have been properly designed and installed in a microwave circuit.

Varian offers stalo cavities to match every klystron oscillator in its present catalog, providing stabilization at any desired frequency in C-band, X-band or K-band. Application Engineering Bulletins 14 and 15, on passive stabilization and on phase locking respectively, fully explain the stalo principle of operation and application to microwave circuits. May we send you copies?



VA-1299 Stalo Cavity shown with VA-201B Klystron

GENERAL CHARACTERISTICS OF VARIAN STALOS

(Exact specifications on individual models available in catalog and data sheets)

Short-term frequency stability	As high as 1 part in 10^9
Long-term frequency stability	As high as 1 part in 10^4
Stabilization factor	As high as 120
Noise reduction	Typically by a factor of 20 as compared to the klystron without stalo cavity
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Temperature compensation	As close as one part in 10^6 per degree Centigrade
Tunability	Fixed frequency or tunable types covering as high as 10% of frequency
Environmental tolerance	Suitable for extreme airborne service
Cavity size and weight	Comparable to or less than active stabilization circuits of similar effectiveness

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1960: PGMTT MILESTONE

Last May I had the pleasure of attending the PGMTT Symposium, and although this is somewhat late, I would like to congratulate the Symposium Committee headed by Dave Proctor for an outstanding event. It was the general consensus of opinion that the 1960 Symposium marks a milestone in the history of PGMTT. The theory of holding a symposium in a semi-isolated resort type atmosphere has been proved successful beyond the fondest hope of the San Diego members.

During the course of the symposium I talked with at least 100 attendees, asking them their opinion with regard to the 24 hour concentration. They were universal in their praise. The general comment was that by having both the technical sessions and living facilities in one location, it offered an unparalleled opportunity for exchanging ideas.

Like all good engineers and scientists, many who thought we had reached a peak felt there was even more that could be done to improve future symposia. A few voiced the opinion that with the excellent opportunity offered for intermingling with their fellow engineers, the sessions could have been reduced in length. Another small group felt that the American Plan was undesirable, since it imposed an additional financial burden on those who preferred to eat elsewhere.

There were some opinions pro and con of the technique of distributing reprints of the papers *after* the session. This was somewhat new for PGMTT, and it was hard to assess. No doubt everyone appreciated receiving the papers. Again, a few indicated they would prefer to receive the papers considerably in advance of the meeting. This is a debatable point that will receive more attention in the future.

There were many other points of discussion. The excellent work of Dave Medved and his Technical Program Committee, the fine attendance (520+), the unbelievably (for Easterners) good weather, the planes overhead, the trip to Tijuana, Dave Proctor's cigar, the salt water swimming pool.

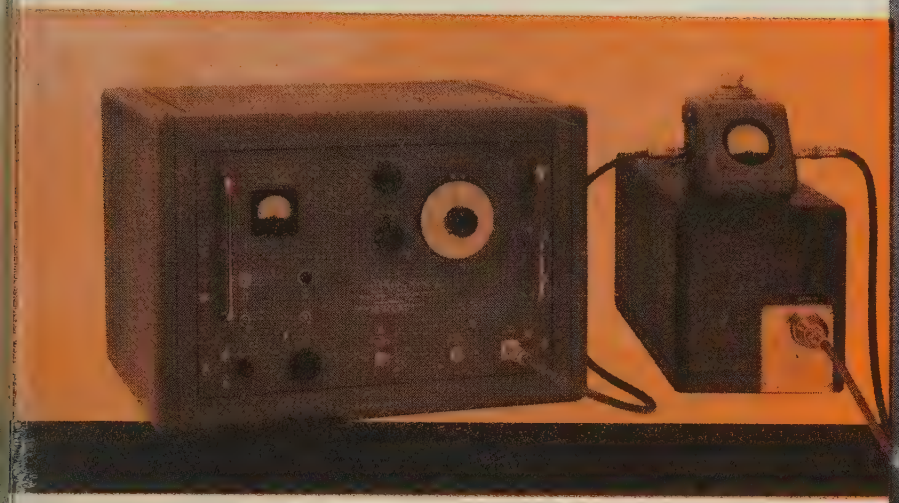
The overall lasting impression that people were left with was that the meeting was a success. PGMTT is strong enough; interest is high enough to have a meeting almost anywhere.

And what of the inference that San Diego is not a center of microwave activity? The 1960 symposium demonstrated for all time that a center of microwave activity can be defined as a place where is located no more than a single microwave engineer who has both interest in his field and a determination to participate. San Diego qualifies many times over.

Ted Saad

Ready for you now!

Primary standard accuracy for power measurements to 1,000 watts!



Frequency coverage dc through 12.4 KMC.

Guaranteed power measuring accuracy of 1%. Probable accuracy better than 0.5%. Precise ac wattmeter, calorimeter and heat exchanger in one neat, rack unit. Separate dual loads for dc to 4 KMC, also C, XB, X bands. Direct reading linear scale.

Above are highlights of the new Sierra 290B Calorimetric Wattmeter Test Set—the industry's closest approach to absolute power measurements in this range.

Model 290B measures power in three distinct modes.

1. For power levels 30 to 1,000 watts, a null-balance mode provides measurement accuracies of 1% or better, with probable error as low as 0.5%.

2. For wider range power levels from 10 to 1,500 watts, a direct-reading mode provides excellent linearity in thermal readout and 2% to 3% accuracy. Readout is fast—60 seconds or less.

3. For expanded scale readings of highest resolution, the above two modes may be combined in a third mode to obtain the order of accuracy of the null-balance mode, together with the time-saving convenience of the direct readout mode.

Model 290B, $4,500.00. (Water loads, extra.)

Data and prices subject to change without notice. Prices f.o.b. factory.

Sierra 290B Test Set

Laboratory setup above shows Sierra Model 215 Power Source being used in conjunction with Model 290B Calorimeter to calibrate Sierra Bi-Directional Power Monitor. Designed specifically for calibration purposes, 215 series Sources include four 50 watt models covering, collectively, 25 to 1,000 MC. Model 215A, 25 to 50 MC; Model 215B, 50 to 150 MC; Model 215C, 150 to 470 MC; Model 215D, 470 to 1,000 MC. Price (any model) $3,300.00.

For complete details, see your Sierra representative or write direct

SIERRA ELECTRONIC CORPORATION

A Division of Phiico Corporation

6560C BOHANNON DRIVE • MENLO PARK, CALIFORNIA • DAvenport 6-2060

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Canada: Atlas Instrument Corporation, Ltd., Montreal, Ottawa, Toronto, Vancouver.
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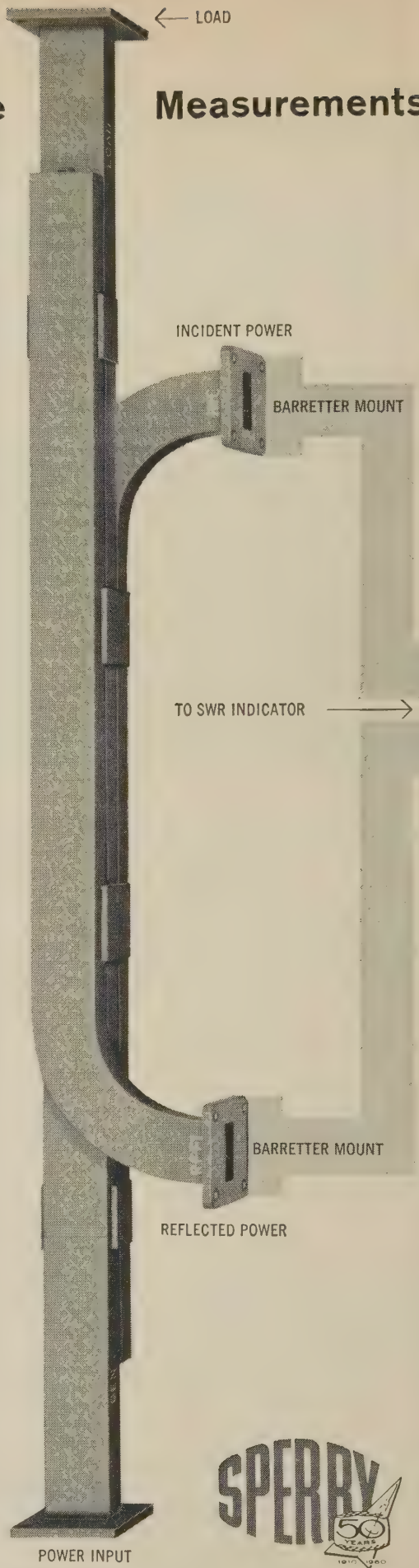
sierra

For direct, accurate Microwave Measurements...

AVAILABLE NOW

Microline®

REFLECTOMETER COUPLERS



Microline Reflectometer Couplers provide a quick, simple and accurate means of measuring voltage standing wave ratios. Each is actually two couplers, and can do many of the jobs of two, yet is considerably more compact.

The outputs of the coupler at the barretter mounts are incident power and reflected power respectively. These outputs may be coupled to the Microline 29A1 SWR Indicator through a 29A2 Input Switch; by noting differences in db, VSWR may be simply calculated. The Input Switch provides convenient audio switching between the barretter mounts.

With one arm terminated (normally the "REFL" arm), the other can be coupled to a frequency meter, or to power measuring or other monitoring equipment, and used as any standard coupler. With both the "Load" and "REFL" arms terminated—using matched components such as Microline 42 or 43 series terminations—the coupler serves as an excellent fixed attenuation standard, unaffected by variations in temperature or humidity. Calibrated against primary attenuation standards, the coupling values of this circuit become the attenuation values at all frequencies over the range.

Available for immediate delivery from stock, the Reflectometer Couplers are another in the Microline family of high quality, matched microwave instruments . . . the most complete, most dependable, most advanced line for today's high precision microwave applications.

SPECIFICATIONS:

Frequency Range:	Waveguide Size:	Recommended Barretter Mount	Recommended Barretter
Mod. 24S1 . . 2.60-3.95 kmc	3" x 1½"	33S2	821
Mod. 24C1 . . 3.95-5.85 kmc	2" x 1"	33C2	560
Mod. 24X1 . . 8.2-12.4 kmc	1" x ½"	33X2	560

Nominal Coupling: 10db
VSWR of Primary Line: 1.05
Coupling Variation Over Range: ± 0.5
Tracking Between Arms: ± 0.05db
Minimum Effective Directivity: 40db

PRICES: Mod. 24S1, $600
Mod. 24C1, $350
Mod. 24X1, $175

CONTACT: LOUIS A. GARTEN & ASSOCIATES: WEST ORANGE, N. J. 645 Eagle Rock Ave., REdwood 1-1800; NEW YORK, N. Y. BOwling Green 9-4339; PHILADELPHIA, PA. 730 Washington Lane, Jenkintown, WAverly 7-1200.
TECHNICAL INSTRUMENTS, INC.: READING, MASS. 90 Main St., REading 2-3930; LIVERPOOL, N. Y. 916 Liverpool Rd., OLdfield 2-2535; BRIDGEPORT, CONN. 1115 Main St., FOrest 8-4582.

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Circle Reader Service Card 7

Matched *Microline*® Instruments

IMMEDIATE DELIVERY

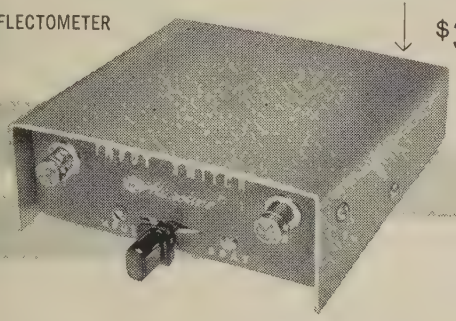
A2

NPUT SWITCH

e Microline 29A2 Input Switch is an accessory for use with SWR Indicator, providing audio switching between two uts. In an appropriate circuit it will permit direct reading insertion loss. A gain adjustment is provided on one of the uts. This adjustment does not affect bolometer bias. Con- cted as illustrated, the SWR Indicator, 29A2 Input Switch d a Microline Reflectometer Coupler with barretter mounts m a versatile reflectometer for impedance measurement.

M REFLECTOMETER PLER

$30



A1

SWR INDICATOR

$200

he ideal amplifier for measuring standing wave ratios and lative power in microwave systems . . . and the ideal indi- tor in frequency measurement. It is the only instrument oviding two bandwidth selections: Wide Band, 300-5000 s (fixed); or Narrow Band, 30-150 cps (variable), with sultant high stability, sensitivity, and freedom from modu- tor drift error.

The 29A1 incorporates an expanded scale and automatic mpensation for increased accuracy in low VSWR measure- ent. A "Plus 5 db" gain step facilitates accurate upper-scale adout on the meter. Many other advantages, such as a push- tton bolometer current reading . . . positive diode protec- on against bolometer burnout . . . "wide" position switching minating the tuned circuit . . . easy readability and oper- ility . . . make the 29A1 the most desirable instrument of kind. It is handsomely designed—a light blue case, brushed uminum control panel, and contrasting gray sub-panel.

Available for immediate delivery from stock, the SWR dicator is another in the Microline family of high quality, atched microwave instruments . . . the most complete, most pendable, most advanced line for today's high precision icrowave applications.

SPECIFICATIONS:

Frequency:	1000 cps, ± 1%
Sensitivity:	0.1 uv at 200 ohm level for full scale deflection.
Noise Level:	Less than 0.03 uv referred to input, narrow-band position.
Amplifier Bandwidth:	Wide band position, 300-5000 cps; Narrow band position, continuously adjustable, 30-150 cps.
Calibration:	Meter reads SWR, db, bolometer current.
Range:	70 db. Input attenuator provides 60 db in 10 db steps. Accuracy 0.1 db per step.
Meter Scales:	SWR 1-4, SWR 3-10, Expanded SWR 1-1.3, db 0-10, expanded db 0-2, bolometer current 0-10 ma.
Gain Control:	30 db.
Input:	BNC female.
Input Positions:	High Bolo—8.4 ma bolometer position, 200 ohms. Low Bolo—4.3 ma bolometer position, 200 ohms. 200—200 ohms for crystal rectifier. Hi-Z—high impedance for crystal rectifier.
Output:	Jack provided for 0-1 ma recorder, 1 side grounded, 1500 ohm resistance. Jack for audio output.
Power:	115/230 volts, 50-60 cps.
Size:	Approx. 8 x 11 x 12.
Weight:	14 lbs.
Price:	$200.

NTACT: LOUIS A. GARTEN & ASSOCIATES: WEST ORANGE, N. J. 645 Eagle Rock e., REdwood 1-1800; NEW YORK, N. Y. BOwling Green 9-4339; PHILADELPHIA, . 730 Washington Lane, Jenkintown, WAverly 7-1200.

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SPERRY 50 YEARS

PERRY MICROWAVE ELECTRONICS COMPANY, *CLEARWATER, FLORIDA · DIVISION OF SPERRY RAND CORPORATION*

A MICROWAVE ENGINEER'S VIEW OF MATERIALS

DR. SEYMOUR B. COHN
ASSOCIATE EDITOR
the microwave journal

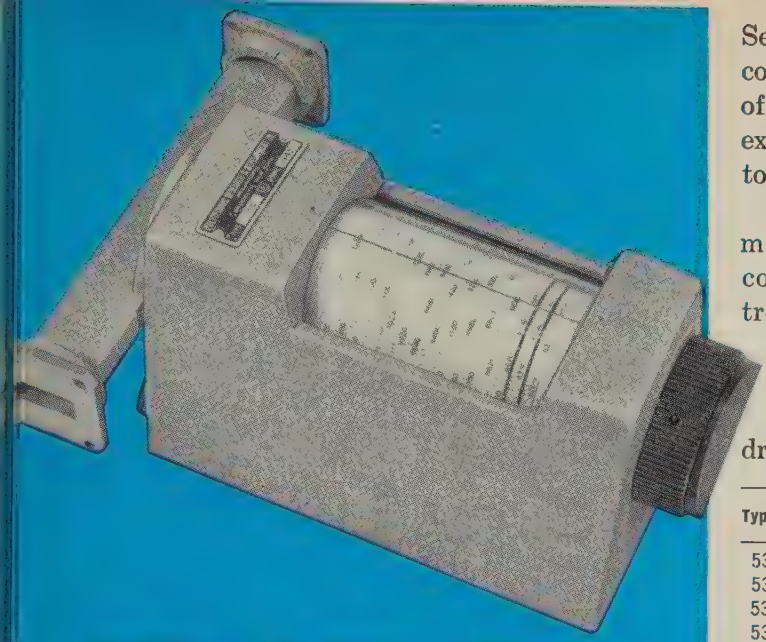
We microwave engineers are completely dependent upon the materials available for our use. As a rule we are highly expert in applying these materials, but are usually not trained to understand their intrinsic natures. For the engineering of new or improved materials we rely on solid-state physicists, chemists, plastics engineers, metallurgists, and other practitioners of arts mysterious to us. They have treated us well indeed, giving us excellent dielectrics, magnetic media, plating processes, and many unique kinds of semi-conductor elements. We certainly have no cause to complain about the abundance of good materials, processes, and new principles that have been handed us to exploit.

But let us think what we could do if some really major advances in materials were made now. Consider dielectrics, for example. Microwave engineers have been using polystyrene, polyethylene, and teflon for about 20 years. These offer loss tangents of the order of 0.0003, equivalent to Q's of about 3000. But suppose we had something better by an order of magnitude, offering loss tangents of 0.00003, or Q's of 30,000. We could quickly put this material to use in miniature, very-high-Q resonant cavities, in extremely low-loss dielectric transmission lines, in really high-quality photo-etched strip-line circuits. For most applications dielectrics would no longer present a loss liability, and conductor loss would be the limiting factor.

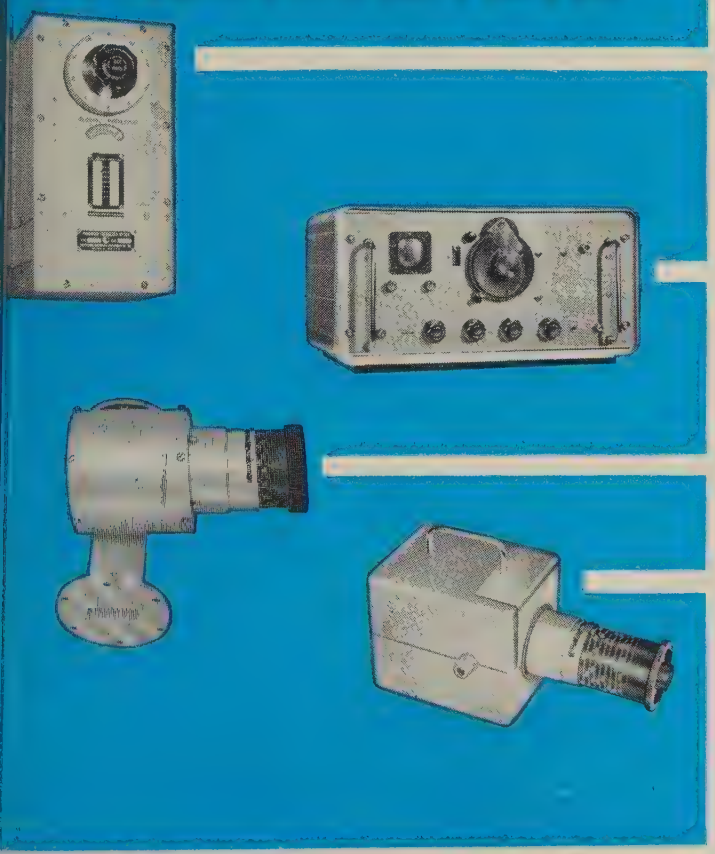
Good conductors have a much longer history than good dielectrics. Since Georg Ohm's day, no better conductors than silver and copper have been found. These are the most favored conductors for microwave use, with aluminum also used, although somewhat inferior. By going to extreme temperatures, improvements in conductivity can be obtained. For example, conductivity of metals increases as the temperature is decreased. However, true superconductivity is a low-frequency phenomenon, not occurring in the microwave range. With some other kinds of materials, conductivity increases with temperature. For example, a plasma raised to 100,000,000 degrees centigrade is a far better conductor than is silver at room temperature. But what we really want is a vast improvement in conductivity under normal conditions. We cannot expect to operate ordinary microwave circuits and transmission lines at temperatures characteristic either of remote space or of the interior of the sun. Nevertheless, something practical may be possible. Couldn't, for example, the atomic structure on the surface of a metal be rearranged to impede microwave currents much less than does the naturally semi-ordered surface of silver or copper?

Since ferrite materials were put to practical microwave use about ten years ago, they have been enormously improved and adapted. The most recent material of this

(*Continued on page 16*)



PRD PACEMAKER LINE



Seven full waveguide bandwidths are each covered by a separate meter in this 532 series of nine reaction-coupled frequency meters, extending over the complete range from 3.95 to 40.0 kmc/s.

These frequency meters consist of a TE_{111} mode cavity resonator tuned by a non-contacting plunger. Ruggedness for long trouble-free life is assured by the all-metal housing. Maximum readability, resolution and accuracy to ±0.08% are the result of an optimized design distinguished by a drum type spiral scale more than 8 feet long.

Type No.	Frequency Range (kmc/sec)	Waveguide (Size in Inches)	Flange	Accuracy (%)	Price
532	3.95 to 5.85	2 x 1	UG-149/U	±.08	$380
533	5.85 to 8.2	1½ x ¾	UG-344/U	±.08	$295
534	7.0 to 10.0	1¼ x ⅝	UG-51/U	±.08	$290
535	8.2 to 12.4	1 x ½	UG-39/U	±.08	$175
536	12.4 to 18.0	.702 x .391	UG-419/U	±.1	$285
537	18.0 to 26.5	.500 x .250	UG-425/U	±.1	$290
537-F1	18.0 to 26.5	.500 x .250	UG-595/U	±.1	$290
538	26.5 to 40.0	.360 x .220	UG-381/U	±.2	$300
538-F1	26.5 to 40.0	.360 x .220	UG-599/U	±.2	$300

BROADBAND DIRECT READING FREQUENCY METERS

Most Complete Line... For Every Purpose, Every Budget

High Precision, Direct Reading Meters (0.015%)

Series 555 to 579 consists of 30 different types covering from 0.925 to 39.0 kmc/s. Representing highest state of the art, these frequency meters fully qualify as transfer or secondary standards for exacting laboratory or production service. Features include: hermetically sealed invar cavity, temperature-compensation, high Q, optimum cavity geometry, high conductivity plating. Price range: $1200.-$1500.

Precision Heterodyne Frequency Meter (0.002%)

PRD 504, for 100 to 10,000 mc/s with accuracy of 0.002% at crystal check points every 5 mc/s and 0.03% or better between check points. Automatic interpolation by unique patented spiral-scale dial. Beat indication by both external earphones and built-in CRT. Meter is self-contained and portable. Price: $695.

Inexpensive, Direct Reading Meters (0.08%)

Series 585-A to 590-A affords excellent accuracy at lowest cost from 5.1 to 10.0 kmc/s. Ideally suited for panel mounting and systems use. Price range: $150.-$350.

Direct Reading UHF Meter (±0.2%)

PRD 587-A, covers range 250 to 1000 mc/s. Spiral drum scale 60 inches long enables precision direct reading. May also be used as a tunable narrow band filter. Price: $275.

PRD ELECTRONICS, INC.
A Subsidiary of Harris-Intertype Corporation
Formerly Polytechnic Research & Development Co., Inc.

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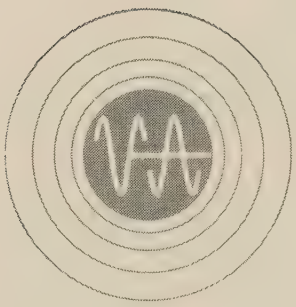
2639 So. La Cienega Blvd., Los Angeles 34, Calif., UPton 0-1940

OUTSTANDING LATITUDE OF PERFORMANCE

EXCEPTIONAL CHOICE OF OPTIONS



VARIAN 6-INCH

Quality that passes both high-field and wide-gap tests

The two accompanying field plots show the wide latitude of performance of the Varian 6-inch magnets: a large area of homogeneous field at moderate field strength and wide air gap; a small, but usable area of homogeneous field even at strengths as high as 17,000 gauss. In addition, an equivalent degree of time stability is provided by the matching Varian power supply. All these aspects of performance demonstrate the depth of technology behind Varian Magnet systems.

Useful differences in the choice of models

Rotation of the magnetic field about the vertical axis is a capability provided by the rotating V-4007-1. Also, for higher fields this model will accept the full 2 ampere output of a larger optional power supply, the V-2100B. Varian's other 6-inch magnet, the fixed-azimuth V-4007, is lower in cost, provides a wider selection of gap widths, and has an adjustable yoke that permits convenience and flexibility of access to the gap. Varian also offers rotating and fixed-azimuth 12-inch magnet systems.

Pole-cap options to meet varied requirements

Choice of pole caps available includes cylindrical, tapered, adjustable ring-shim and constant gradient types. Highest fields are provided by tapered pole caps. Largest homogeneous volume is available with the adjustable ring-shim type. Various gap widths on the V-4007-1 rotating magnet are provided by a choice of pole cap thicknesses. On the V-4007 the gap is varied by separating the yoke with pairs of precision ground spacer blocks.

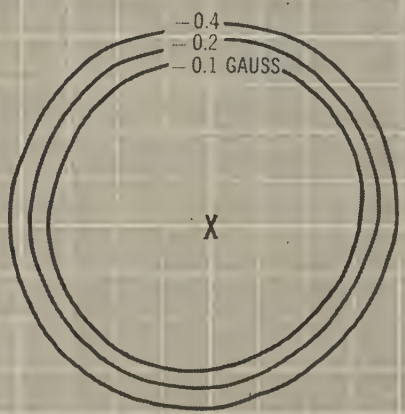
Circle Reader Service Card 10

LABORATORY MAGNETS

At 17,000 Gauss

Full-scale plot of homogeneous field in 0.75-inch air gap and 17,000 gauss field on a Varian 6-inch electromagnet with tapered pole caps of 4.0 inch face diameter. Plot taken in median plane of air gap.

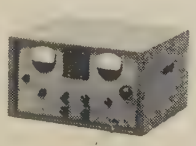
At 2¾-inch Air Gap



Full-scale plot of homogeneous field at 4,600 gauss on a Varian 6-inch electromagnet with adjustable ring-shim pole caps and a central air gap of 2.75 inches. Plot taken in median plane of air gap.

Delivery 30 to 45 days after receipt of order can be provided on most magnet systems.
For full specifications on the Varian Magnets, write the **Instrument Division.**

Varian NMR Fluxmeter provides precise measurement and/or control of magnetic fields, as an accessory to the Varian 6- and 12-inch magnet systems.



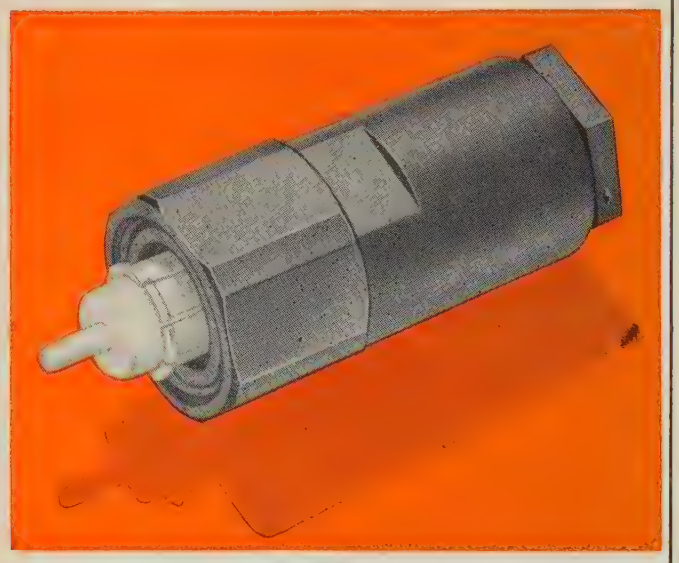
VARIAN associates
PALO ALTO 34, CALIFORNIA

NMR & EPR SPECTROMETERS, MAGNETS, FLUXMETERS, GRAPHIC RECORDERS, MAGNETOMETERS, MICROWAVE TUBES, MICROWAVE SYSTEM COMPONENTS, HIGH VACUUM EQUIPMENT, LINEAR ACCELERATORS, RESEARCH AND DEVELOPMENT SERVICES

TAPCO MICROWAVE COMPONENTS

LT SERIES HIGH VOLTAGE COAXIAL RF CONNECTORS

These TAPCO connectors are designed for transmission of high power RF energy in airborne electronic systems. Presently available in sizes for RG-119/U, RG-209/U and RG-211/U coaxial cables. Design adaptable to other cable sizes.



SPECIFICATIONS—Type: LT, straight and right-angle configuration. **Frequency Range:** 0 Mc/s to 5000 Mc/s. **Power Handling:** 1000 watts, average. **VSWR:** 1.2:1 maximum with 50" cable assembly. **Temperature:** –54°C to 95°C. **Altitude:** 70,000 feet.

SPECIAL CHARACTERISTICS—Moisture sealed in mated and unmated condition. Sliding coupling nut permits complete mating prior to thread engagement. Cable grips easily attached. Lightweight, aluminum construction.

Advanced engineering projects at TAPCO *offer excellent career opportunities for qualified engineers and scientists. Write Director of Employment.*

TRW

TAPCO GROUP

Thompson Ramo Wooldridge Inc.

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DESIGNERS AND MANUFACTURERS FOR THE AIRCRAFT, MISSILE AND SPACE, ORDNANCE, ELECTRONIC AND NUCLEAR INDUSTRIES

Dr. Cohn

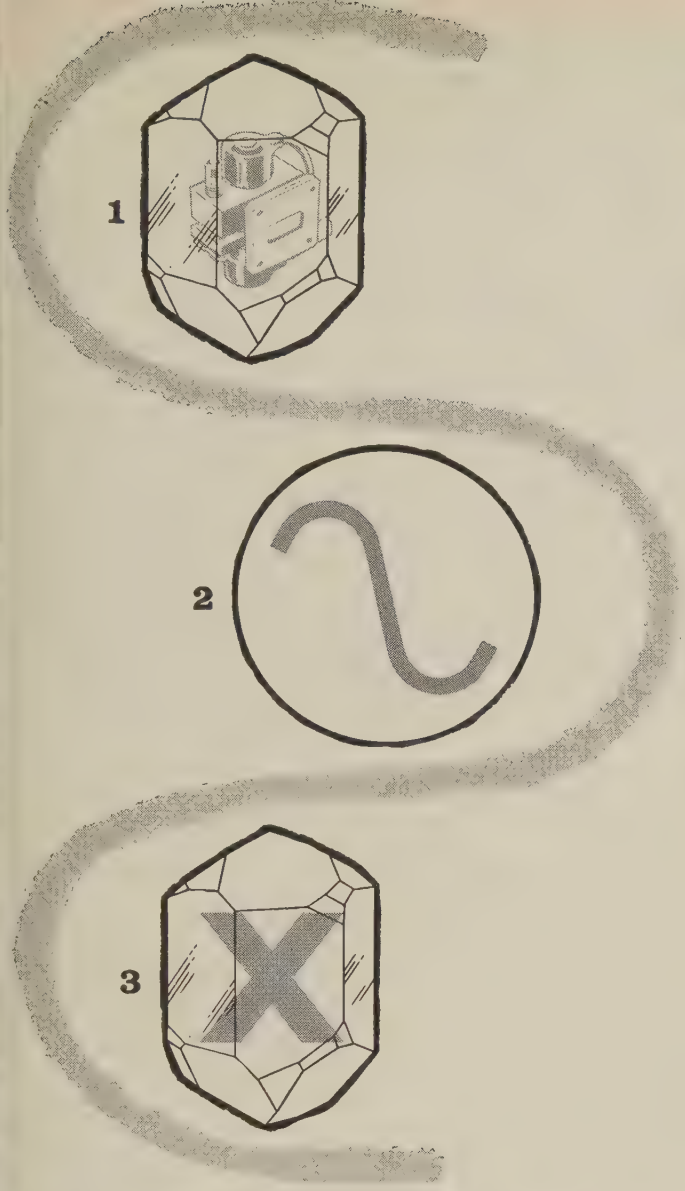
(*Continued from page 12*)

class, yttrium iron garnet, offers in its single-crystal form line widths about 1000 times narrower than those of the earlier polycrystalline ferrites. This makes possible the use of tiny spheres of garnet as microwave resonators with Q values close to that of conventional waveguide cavities. We cannot predict, of course, whether materials engineers and physicists can perform still another miracle, and improve on yttrium-iron garnet. But if they do give us another order of magnitude of improvement, we will certainly make use of it. Some applications of magnetic materials that now seem to be just at the edge of feasibility would at last be practical. These are, for example, parametric low-noise amplification with low pump power, high-efficiency frequency multiplication at low input levels, and high-performance switches. Perhaps even maser, spin-echo, and frequency-translation techniques now requiring paramagnetic materials near absolute zero might become possible at room temperature.

Solid-state engineers and physicists have given us semiconductor mixer elements, detectors, varacters, and, most recently, tunnel diodes. Perhaps it is presumptuous of us to ask for more. But there *is* room for improvement. Nonlinear-resistance-type mixers now are capable of conversion efficiencies of about -4 db and noise figures of about 5 db. If, however, their resistance-versus-voltage characteristic could be made to approximate more nearly an abrupt transition from infinite to zero resistance, conversion efficiencies and noise figures of 0 db could be approached. Needless to say, switching circuits using these elements would also be vastly improved. Parametric amplifiers utilizing varacters are now practical at the lower microwave frequencies, but to be useful at the higher frequencies, the Q of these semi-conductor elements must be raised by about a factor of ten. This improvement would also make more practical other components such as voltage-controlled phase shifters, modulators, frequency multipliers, switches, and voltage-tuned filters.

I have left for last the material that many of us would like most, but that we least expect — a magnetic wall. Our theoretical analyses repeatedly call for magnetic walls, but they may be found only in textbooks. If they could be obtained "off the shelf," think how useful they would be. With magnetic walls built into our components, many of our designs could be *exact* instead of approximate. Fringing fields could be eliminated. Leakage of power could be prevented. Waveguide and cavity modes now known only theoretically would become practical. New varieties of antennas and circuit elements could be invented. But the discovery of a practical magnetic wall is probably as unlikely as the discovery of anti-gravitational matter. Undoubtedly we will have to continue without its use.

These are the materials microwave engineers would like for their work. More such as these are easily thought of. It is significant, however, that the things we think we want are all extrapolations of what we already are familiar with experimentally or theoretically. Most likely when the next breakthrough in our field comes, it will turn out to be something entirely different. Something that will take us as much by surprise as did ferrites, varacters, and tunnel diodes when they first appeared upon our scene.



3 approaches to MICROWAVE STABILITY

3 different "state-of-the-art" approaches for achieving microwave frequency stability are utilized in the LFE Oscillators described below. Each of these instruments exemplifies LFE's leadership in this specialized field. Separate data bulletins are available on each series. Write for a full set today.

	1 Crystal-Locked Klystron Approach	2 Dual Mode Reference Cavity Approach	3 Crystal Multiplier Approach
LFE MODELS	Series 820-XLK Crystal-Locked Klystron Source	Series 814 Ultra-Stable Microwave Oscillator	Model 5010 S-Band Exciter
FREQUENCY RANGE	S-band to K-band fixed frequency	27 tunable models covering 2.5 mc —27Kmc	S-band fixed frequency
POWER	Approx. full klystron power	Up to 500 mw @ X-band or 1.5 w @ C-band	125 mw
SHORT-TERM STABILITY	1 part in 10^8	5 parts in 10^8	1.2 cps (incidental FM)
LONG-TERM STABILITY	1 part in 10^6 (24-hour period) Generally independent of environmental conditions	1 part in 10^6	Less than 100 kc drift over 25-hr. period

LFE

INSTRUMENT DIVISION

LABORATORY FOR ELECTRONICS, INC.

714 BEACON STREET • BOSTON 15, MASSACHUSETTS

WESTERN REGIONAL OFFICE, 211 South Beverly Drive, Beverly Hills, California.

Circle Reader Service Card 12

Industry News

A new concept in traveling technical shows, officially known as the Electronic Instrument Manufacturers' Exhibit, will become a reality this fall. Appearing at five key sites around metropolitan New York and Philadelphia, the mobile exhibit will offer an unusual operational array of complementary laboratory and production test instruments with ranges from dc to 220 kmc.

The project will be jointly sponsored by FXR, Inc., Woodside, N.Y.; General Radio Company, West Concord, Mass.; Lambda Electronics Corp., College Point, N.Y.; Panoramic Radio Products Co., Inc., Mt. Vernon, N.Y.; Sensitive Research Instrument Corp., New Rochelle, N.Y., and Tektronix, Inc., Portland, Oregon.

The exhibits will be named by company-engineer specialists and will be arranged to provide maximum exposure of exhibited items. The sponsors hope that this will provide visitors an unique opportunity to obtain firsthand information on calibration and measurement problems in practically all areas of electronics.

Dates and places of the five exhibit areas will be:

October 5-6: Long Island area, Garden City; Sagamo Room at Roosevelt Field Shopping Center.

October 11: Connecticut area, Norwalk; Treadway In

October 13: New York area, Poughkeepsie; Nelsc House.

October 17: Northern New Jersey area, Cedar Grov The Meadowbrook.

October 19-20: Philadelphia area, Moorestown, N.J Cherry Hill Inn.

Show hours at each location will be from 1:00 to 9:0 P.M.

(*More Industry News on page 20*)

Men who know* prefer

F LUNCHEON MEETING in Sardi's-West, New York City, where plans for the ectronic Instrument Manufacturers' Exhibit were announced. Left to right (seated): ernard Schlessel, president, Panoramic Radio; William D. Marshall, vice president- les, FXR; Simeon Weston, executive vice president, Lambda Electronics, and arvin Steinberg, vice president-sales, Sensitive Research Instrument. Standing — ft to right: Tore N. Anderson, executive vice president, FXR, and William R. Saylor, sales manager, General Radio.

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arra LINE CONTINUOUSLY

VARIABLE ATTENUATOR

Exclusive Features:

- Broadband Impedance Match.
- Min. VSWR for all values of attenuation over band.
- Insertion Loss: 0.2 db max.
- Calibration Accuracy: ±0.2 db.
- Drive: Micrometer
- Connectors: Type "N" Female (others on request).
- Size: 5" dia. x 1" high, excluding connectors and micrometer.
- Power Rating: 10 watts average min.
- Calibration freq.: midband
- Continuously variable for all values of attenuation.

arra Antenna & Radome Research Associates

27 BOND STREET • WESTBURY, N. Y.

You join the ranks of those who know* when you specify McMillan absorbers for *your* "free space" rooms. The list of McMillan customers is a veritable "who's who" in the electronics industry and includes such leaders as — Avco, Bell Labs, Bendix, Cambridge Research Center, Convair, General Electric, Johns Hopkins, MIT Lincoln Labs, Philco, Westinghouse and many others.

McMillan absorbers

* KNOW that from McMillan they can obtain substantiation to back up performance claims — either in simple, concise form or in advanced, scientific data.
* KNOW that each and every piece of McMillan absorber must pass an adequate source inspection to assure conformance to electrical specifications.
* KNOW that McMillan absorbers can easily be attached and removed by anyone, without special tools and without the use of adhesives and the resulting damage to walls.

McMillan

McMILLAN LABORATORY, INCORPORATED

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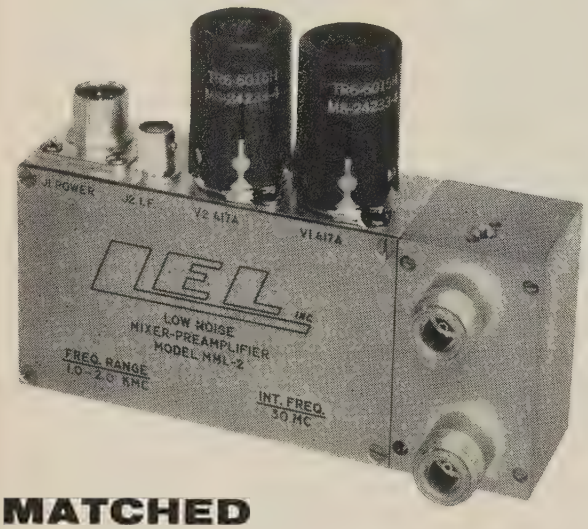
See Us at Booth 534 — WESCON Show, August 23 to 26

7.5db Noise Figure

in L, S or C BAND



MATCHED MIXER-PREAMPLIFIERS

(Waveguide units available for C, X and K bands)

TYPICAL SPECIFICATIONS

Noise Figure	7.5db typical
Bandwidth	8mc
Input Signal	Type "N" Coaxial
Minimum Overall Power Gain	25db
LO Power Requirement	1mw typical

For complete specifications and catalog write:

LEL INC. / Copiague, L. I., N. Y.

(Continued from page 19)

HAZELTINE CORPORATION ELECTS NEW OFFICERS

Directors of Hazeltine Corporation, Little Neck, N.Y. announced the election of Webster H. Wilson as president. The 36 year old electronics firm is listed by the Department of Defense as one of the Nation's leading defense contractors. Mr. Wilson had been executive vice president for operations of Hazeltine Electronics Division and a director of Hazeltine Corporation since 1958. He succeeds William A. MacDonald, who continues as chairman of the board.

Wilfred M. McFarland was elected vice chairman of the board, a position which was recently established. He has been a director since 1953. Mr. McFarland retains his posts as executive vice president of Hazeltine and a president of Hazeltine Technical Development Center, Inc., the Company's Indiana subsidiary.

In another action, the Hazeltine board named Richard L. Beam as chief operating head of Hazeltine Electronics Division. Mr. Beam was elected executive vice president of the division. He has been a director of Hazeltine Corporation since 1958. He succeeds Jennings B. Dow, who recently was elected president of Hazeltine Research Corporation, as head of the electronics division.

Mr. Wilson joined Hazeltine in 1946 and became a chief project administrator and later vice president of the Government and Commercial Department.

Mr. McFarland became a vice president of Hazeltine Corporation in 1951 and executive vice president in 1956.

Mr. Beam, who formerly was executive vice president for engineering of Hazeltine Electronics Division, joined Hazeltine in 1948. He became a vice president of the division in 1955, and during his Hazeltine career, has been in charge of important radar and electronic IFF (identification friend or foe) projects.

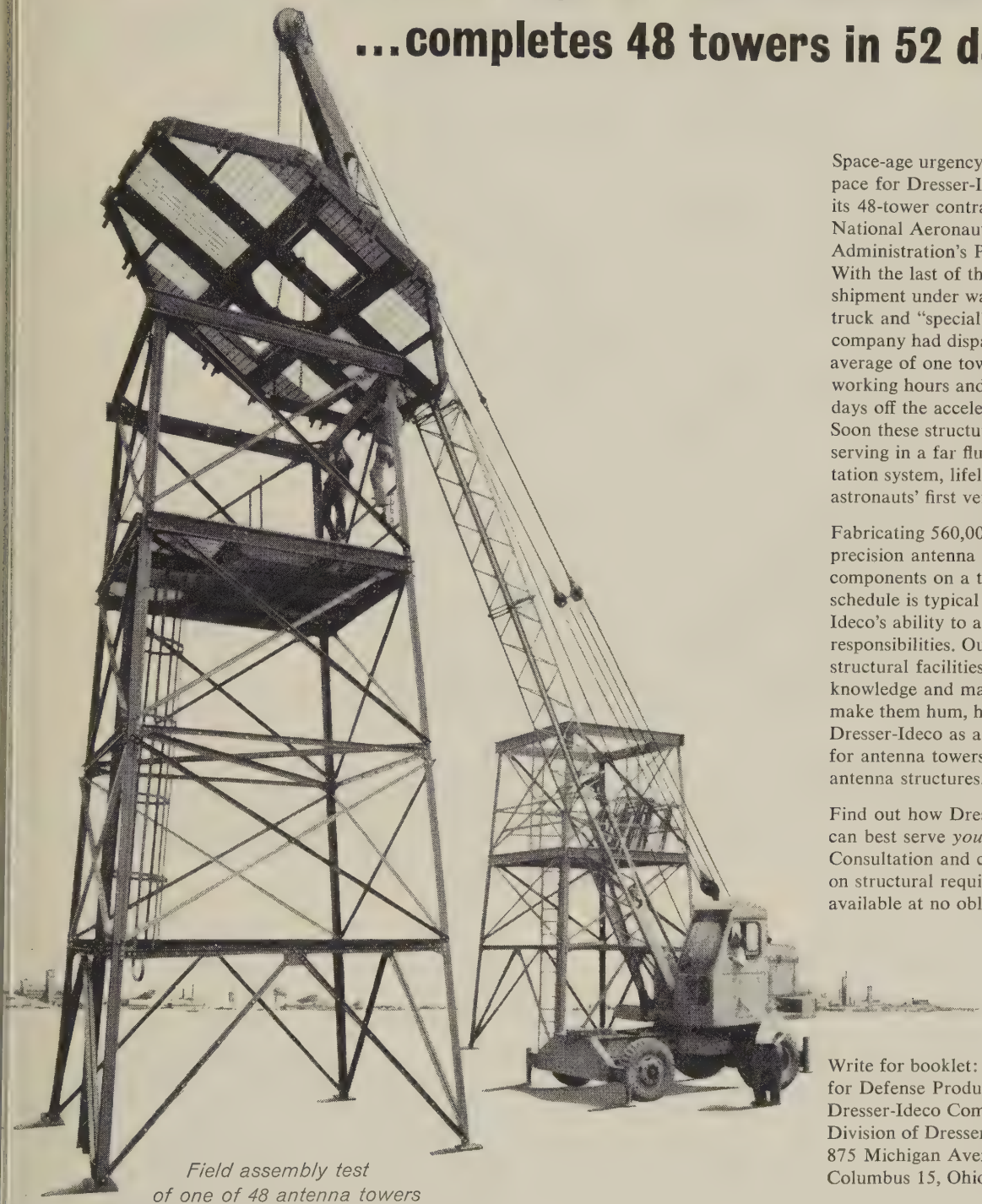
Hazeltine, with headquarters in Little Neck, L.I., has facilities in eleven Long Island communities; Indianapolis, Indiana; Chicago, Ill.; Dayton, O. and Washington, D.C. The company is engaged in the design, development and production of complex electronic equipment and systems. Through its subsidiaries, Hazeltine also is active in developmental work in the radio and television, photographic, office equipment and other industrial fields.

(Continued on page 22)

—mwj—

For PROJECT MERCURY

Dresser-Ideco puts wings on tower construction ...completes 48 towers in 52 days!



Field assembly test of one of 48 antenna towers for the Man-In-Orbit program. This Dresser-Ideco contract included transmitting, receiving and boresight designs.

Space-age urgency set the pace for Dresser-Ideco in fulfilling its 48-tower contract for the National Aeronautics and Space Administration's Project Mercury. With the last of the complete shipment under way via exclusive truck and "special" train, the company had dispatched an average of one tower every nine working hours and shaved 12 days off the accelerated schedule! Soon these structures will be serving in a far flung instrumentation system, lifelining our astronauts' first venture into space.

Fabricating 560,000 pounds of precision antenna support components on a tight delivery schedule is typical of Dresser-Ideco's ability to assume unusual responsibilities. Outstanding structural facilities, and the knowledge and man-power to make them hum, have established Dresser-Ideco as a major source for antenna towers and antenna structures.

Find out how Dresser-Ideco can best serve *your* program. Consultation and cost estimates on structural requirements are available at no obligation.

Write for booklet: "Facilities for Defense Production." Dresser-Ideco Company, A Division of Dresser Industries, Inc., 875 Michigan Avenue, Columbus 15, Ohio.

DRESSER-IDECO COMPANY

DRESSER IDECO®

DRESSER INDUSTRIES INC.

ELECTRONIC • INDUSTRIAL
OIL • GAS • CHEMICAL

Doppler Noise Measurement

The ALLSCOTT Noise Measuring Equipment

PROVIDES:

1. The ability to distinguish between frequency and amplitude modulated noise and to present these spectra independently and with adequate isolation.

2. A narrow-band filter or "window" which may be located for the purpose of making noise power measurements at an accurately known frequency separation from the carrier.

3. A high order of sensitivity.

CHARACTERISTICS:

AM Signal to Noise Ratios in the range — 135db to — 85 db. RMS Frequency Deviations of 0.01 cps in a 70 cps bandwidth within a band of frequencies 1.0 to 90 Kc/s.

Units available for RF frequencies from 8 to 14 Kmc/s.

Oscilloscope display with automatic sweep to give spectrum curve. Thermal microammeter and manual oscillator control for quantitative work.

FERRANTI

FERRANTI ELECTRIC, INC.

ELECTRONICS DIVISION

95 MADISON AVENUE HEMPSTEAD, N. Y.

Industry News

(*Continued from page 20*)

WESCON — AUGUST 23-26 — LOS ANGELES

The Western Electronic Show and Convention, to be held August 23-26 in Los Angeles' new Memorial Sports Arena, was again an advance sellout nearly five months before the event, according to Don Larson, manager.

Larson said that 987 booths for the show had been spoken for before the March 31 deadline for space applications. Booths are allocated on a priority system based primarily on WESCON "seniority."

The 987 booths will fill the two-level Arena proper and a specially constructed annex, both of which will be air-conditioned. Parking for 6000 cars is available near the show site, which is adjacent to one of the segments of the Los Angeles freeway system.

— m w j —

FOURNEY NAMED REPRESENTATIVE BY APPARATUS DIVISION, TEXAS INSTRUMENTS, INC.

Texas Instruments, Inc., Dallas, Texas, announced the appointment of Mr. Dave Fourney to its Apparatus Division, Los Angeles, Calif., regional office, to provide customer service to government, military and industrial agencies in that area. Formerly associated with Sperry Gyroscope Co., Mr. Fourney will primarily handle ballistic missile and space activities.

During his previous 18 years' experience, Mr. Fourney's assignments included field servicing in the areas of military armament, fire-control, radar and navigational equipment for military and commercial customers.

Located in Europe from 1942 to 1945 Mr. Fourney was a senior representative assigned to the Eighth and Ninth Air Forces. In 1946 he introduced the electronic automatic pilot to the Royal Aircraft Establishment in England and directed navigational equipment training in foreign commercial airlines.

A graduate of Virginia Polytechnic Institute, Mr. Fourney holds a BS degree in engineering. He is a member of the Institute of Aeronautical Sciences.

The Apparatus Division of Texas Instruments provides the military and other government agencies with systems in the fields of missile/space electronics, radar, combat surveillance and antisubmarine warfare.

— m w j —

(*Continued on page 32*)

250 MW Signal Generator

Wescon Booth
657, 658

X-BAND

Easier, faster testing of

- **Radar and communications systems**
- **Antennas**
- **Microwave components**

High power enables sensitivity and selectivity measurements to be made on radar and communications receiving systems **by direct connection through the input directional coupler.** Time-wasting disconnection of waveguide assemblies is eliminated! High power also facilitates antenna pattern plotting and insertion loss measurements.

dy®

SPECIFICATIONS

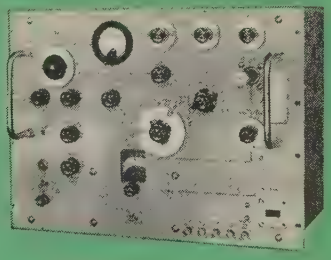
Frequency Range:	8.5 to 10 kmc.
Output Power:	250 mw min. Up to 400 mw at 9.5 kmc.
Power Monitor:	Power settings repeatable within ± 0.5 db. Temperature-compensated.
Attenuator:	Rotary-vane, 0-100 db. Direct reading +24 to −76 dbm. Output accuracy within ±1 db, ±2% of attenuator setting.
Internal Modulation:	Pulse and fm (separately or simultaneously) and square wave.
External Modulation:	Pulse, fm, square wave.
RF Isolation:	Instrument not affected by external rf signal of 1 kw peak or 1 watt average power.
Price:	DY-5381 X-Band Signal Generator: $4,835 f.o.b. factory.

30 MW X-BAND TEST SET

This versatile instrument is a combination signal generator, frequency meter, and power meter for testing radar transmitters, receivers and other X-band equipment. High power available overcomes insertion loss when equipment must be tested via long coaxial cable.

SPECIFICATIONS

Frequency Range:	8.5 to 10 kmc
Output Power:	30 mw guaranteed. 60-85 mw typical
Frequency Meter:	Covers full range. Accurate within 0.03%.
Power Meter:	Includes 25 db attenuator. Total range −6 to +28 dbm.
Attenuator:	Rotary vane, 0-100 db. Attenuates internal power or power from external source.
Input Power Rating:	1 watt maximum.
Internal Modulation:	Pulse or fm.
External Modulation:	Pulse, fm, square wave.
Price:	DY-5003 X-Band Test Set: $3,600 f.o.b. factory.



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See your ℗/DY representative for complete details, or write direct

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Dymec/℗ field representatives in all principal areas

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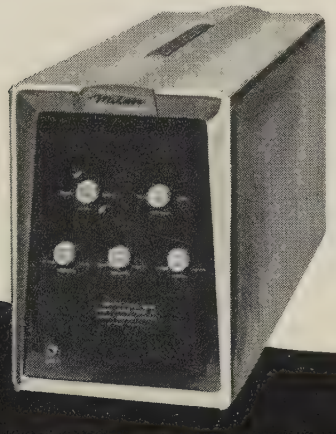
NEW from

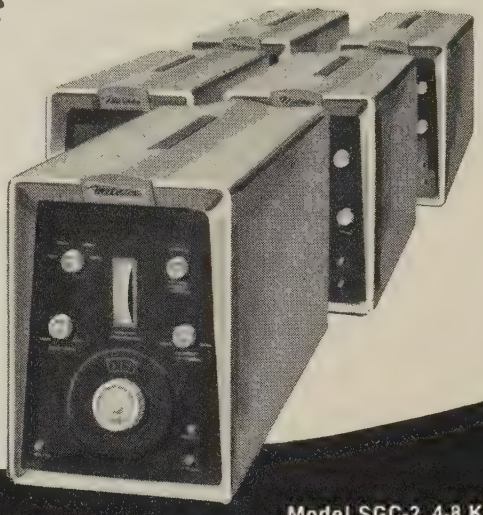
MELABS-

seasoned microwave designers and builders

WESCON
Booth 2224



Model SGO-2, common power supply

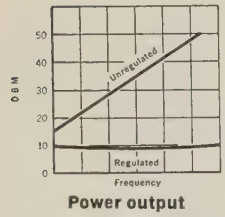


Model SGL-2, 1-2 KMC
Model SGS-2, 2-4 KMC
Model SGC-2, 4-8 KMC
Model SGX-2, 8-12 KMC
Model SGK-2, 12-18 KMC

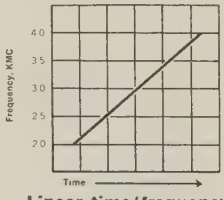
Swept Signal Generators offering Constant Power Output over Entire Band

A common power and sweep supply can be used with any of the new Melabs electronically tuned signal generators covering, respectively, L, S, C, X and K band frequencies.

All five units are compatible with Melabs' radiometer and panoramic display unit. Addition of a receiver box creates a swept receiver or panoramic analyzer. TWT amplifiers with power outputs up to 1 watt can be supplied.



Power output



Linear time/frequency characteristic

SPECIFICATIONS

Model SGS-2, S Band, with SGO-2 Power Supply

Power output:	Regulated, 10 mw ± 1 db; unregulated, 10 mw at 2 KMC, rising to 300 mw at 4 KMC; manual adjustment range, 30 db.
Internal modulation:	For regulated power, pulse, 1-10 μsec; square wave. Rep rate, 100-5000 cps.
External modulation:	Any type, unregulated only.
Sweep:	0.3 to 30 cps; cw through 100% of band.
Price:	Model SGS-2, $2,300.00; Model SGO-2, $900.00;
Specifications similar	Model SGL-2, $2,600.00; Model SGC-2, $2,400.00; Model SGX-2, $2,600.00; Model SGK-2, $4,500.00.

Data subject to change without notice. Prices f.o.b. factory.

Employment opportunities at Melabs are exceptional for ambitious engineers and physicists; write in confidence.

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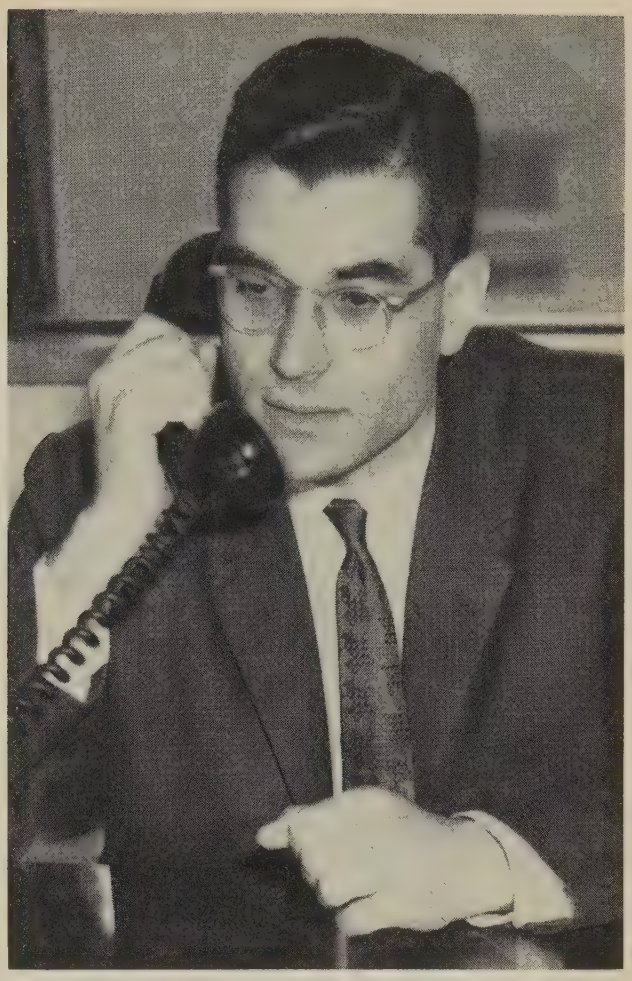
Dr. Arthur A. OLINER

RESEARCH PROFESSOR
Electrical Engineering

MICROWAVE RESEARCH INSTITUTE
POLYTECHNIC INSTITUTE
Brooklyn • New York



The profile begins in the Orient with the British-ducated son of a man in the export-import business. In-rmediate chapters include high school and college in ooklyn, graduate studies with some of the most eminent mes in the history of physics, and a decade and a half productive research and teaching. The most recent apter, which is a reflection on prestige and international outation, concerns a return to the Orient as the invited est of three Japanese scientific societies.

Dr. Arthur A. Oliner, National Chairman of the over 00-member IRE Professional Group on Microwave eory and Techniques, and Research Professor of Electri- Engineering at the Microwave Research Institute, Poly-hnic Institute of Brooklyn, was born in Shanghai, China, 1921. When he was nine, his family returned to the s exotic climes of Brooklyn, where he soon lost the itish accent acquired in elementary school in China.

He had an early interest in scientific things and, while high school, he earned some money with a friend re-iring radios. Upon graduation from high school he won e Physics Medal. He began his studies at Brooklyn Col-ge as a chemistry major, but soon switched to physics cause of the ability of the excellent physics department stimulate him in that direction. Dr. Oliner comments at "my teaching methods today were undoubtedly strong-ly influenced by what I learned then, particularly from Profs. Kurrelmeyer and Mais." Upon his graduation Magna Cum Laude he received the first graduate assistantship to Cornell University ever awarded to a Brooklyn College physics major.

At Cornell University he taught sophomore physics, participated in an Office of Scientific Research and Development research project, and took graduate courses under such famous men as Profs. H. A. Bethe and P. Debye. He almost interrupted his graduate studies to accept a post at Los Alamos, but was prevailed upon to first complete his doctoral thesis. By the time he received his Ph.D. the war was over, however.

While a graduate student, he also found time for enlarging his liberal arts education, and attended courses in philosophy, history and music. In fact, much of his spare time was spent in listening to music, and he developed a deep and lasting taste for chamber music. To this day, he finds relaxation in this pastime. In those days his favorite composers were Brahms and Beethoven, but today he prefers Mozart, Bach and Schubert. He also engaged in athletics, and once placed second on the parallel bars in a collegiate gymnastics meet.

(*Continued on page 28*)

COMPREHENSIVE MICROWAVE COMPONENT CAPABILITIES

This modern three-quarter-acre plant has significantly expanded the services and production capabilities of Microwave Associates' experienced Waveguide Components Division. This new research and production facility is one of the most completely equipped on the east coast. A large 3′ x 2′ capacity dip-brazing unit as well as complete plating and other shop facilities are now handling both large volume and custom-engineered orders. Components are precision-machined and produced in beryllium-copper, cast and fabricated aluminum, and cast magnesium.

Over 500 microwave components for applications from 1.12 to 90.0 kMc/s are standard items. Our Sales Engineers will gladly discuss current work in sophisticated components and RF packaging with you.

A FEW OF THE MANY COMPONENTS MANUFACTURED HERE

New High-Power Varactor Harmonic Generators — excellent suppression of unwanted harmonics and record power levels are available from these solid-state harmonic generators.

New Cast Bends — Zero bend radius — 90° E and H plane bends in S through Ka bands . . . Each bend is compensated to a VSWR of 1.05 over its entire waveguide band.

Sidewall Hybrid Couplers (3db) and H-Plane Folded Hybrid Tees — Cast in aluminum and beryllium-copper are available in S through Ka-band models.

Two New Catalogs — Waveguide Components Short-form Catalog (CSF-60) gives data on over 500 items of waveguide components and test equipment.

Pressure Window Catalog (12 pages) contains electrical and mechanical data on a complete line of glass-kovar, mica, and special pressure windows plus valuable installation and testing tips.

MICROWAVE ASSOCIATES, INC. Burlington, Mass. • Western Union FAX • TWX: Burlington, Mass. 942 • BRowning 2-3000
Export Sales: Microwave International Corporation, 36 West 44th St., New York, New York

A broad new dimension in capability!

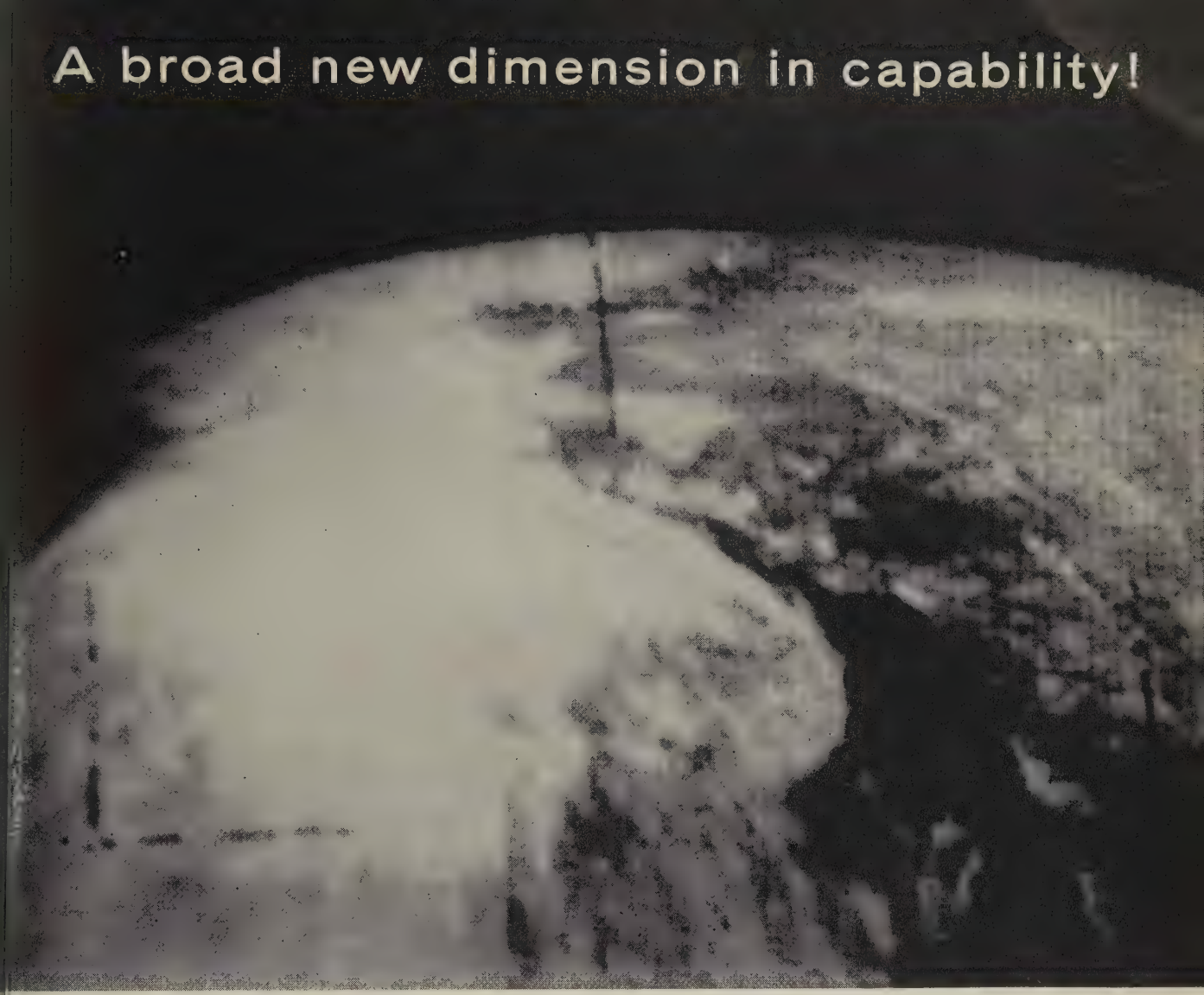


Photo: From Tiros I, altitude 450 statute miles. Location, several hundred miles east of Atlantic coast. Courtesy-National Aeronautics and Space Administration.

Solid day-by-day staff and facilities expansion, coupled with Gorham's recent acquisition of Pickard & Burns,combine to create an entirely new dimension in integrated design, manufacturing, test and research services. If the scope of your operations span ANTENNA SYSTEMS, MICROWAVE DEVICES, SLIP RINGS AND ELECTRO-MECHANICAL DEVICES, look now to Gorham Electronics for idea exploitation in the laboratory, prototype engineering, quantity production, and assembly.

To bring this new capability dimension into perspective for you — Gorham Electronics offers this comprehensive brochure. Write for copy.

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PB PICKARD & BURNS, INC., SUBSIDIARY OF GORHAM MFG.CO., NEEDHAM 94, MASS.

Circle Reader Service Card 21

Dr. Oliner

(*Continued from page 25*)

In 1946 Dr. Oliner accepted what he thought would be a short term position as a senior research associate at Brooklyn Poly's Microwave Research Institute. It was at this time, though, that Dr. Nathan Marcuvitz returned to the Polytechnic from MIT's Radiation Lab where he had spent the war years. "Marc came back from the Rad Lab with a vast array of new methods and new techniques for the solution of electromagnetic field problems and microwave networks," says Dr. Oliner. "I was stimulated by his views and felt a tremendous sense of challenge when this wealth of material became available."

Dr. Oliner decided to remain at MRI and since that time his research endeavors, singly and with Dr. Marcuvitz or others at the Polytechnic, have resulted in more than 20 published papers in various aspects of the microwave field including equivalent circuit studies of slots, precision measurement methods, microwave network techniques, strip transmission lines, periodic structures, surface waves and leaky wave antennas. In 1957 he was promoted to full professor.

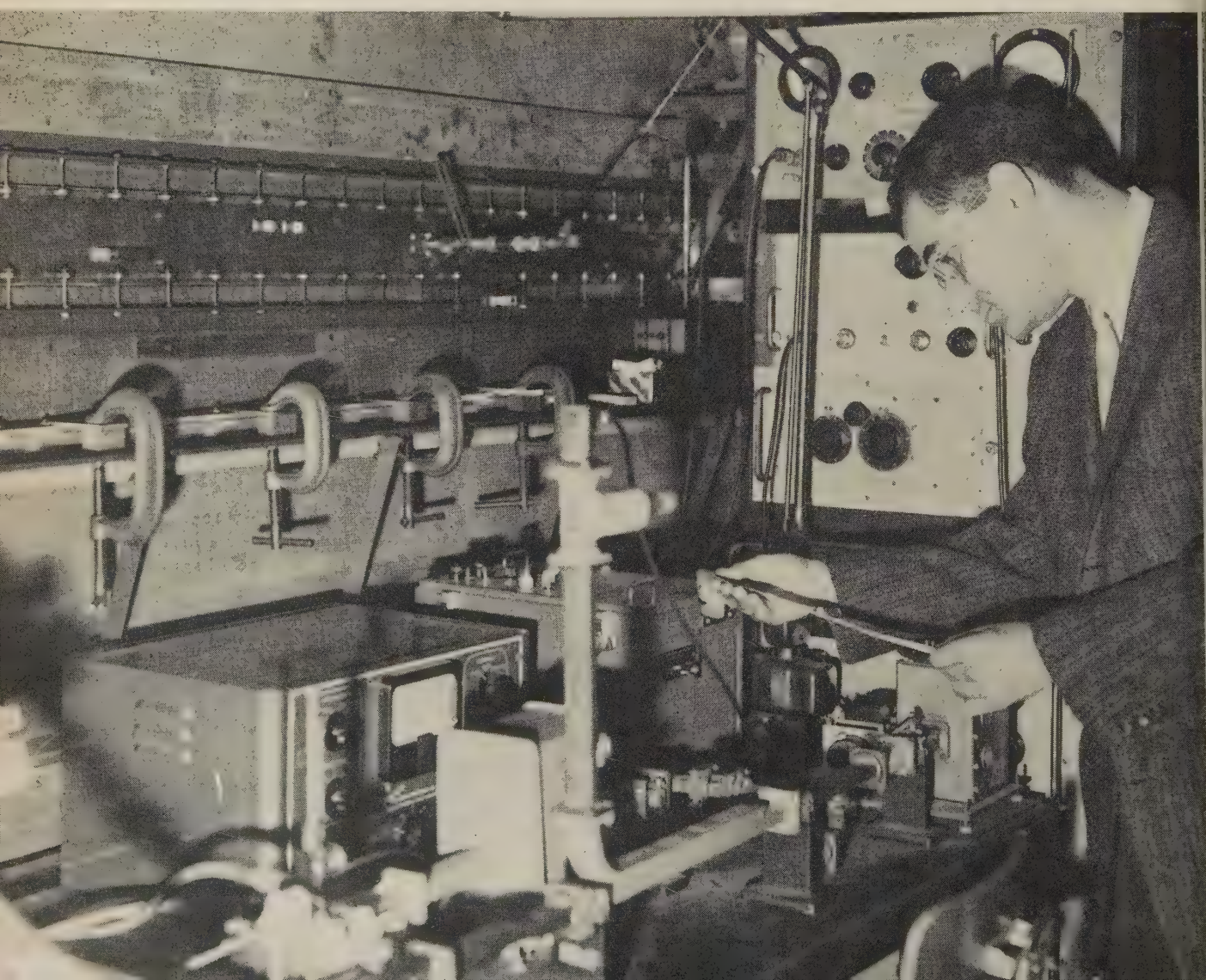
For the past few years, again in collaboration with D Marcuvitz, Dr. Oliner has been writing a book on "Micro wave Network Theory and Applications." Teaching load research interests, administrative duties, and myriad ob ligations including his work with IRE have caused slow going, but the authors intend to complete the writin since the need for such a book still exists.

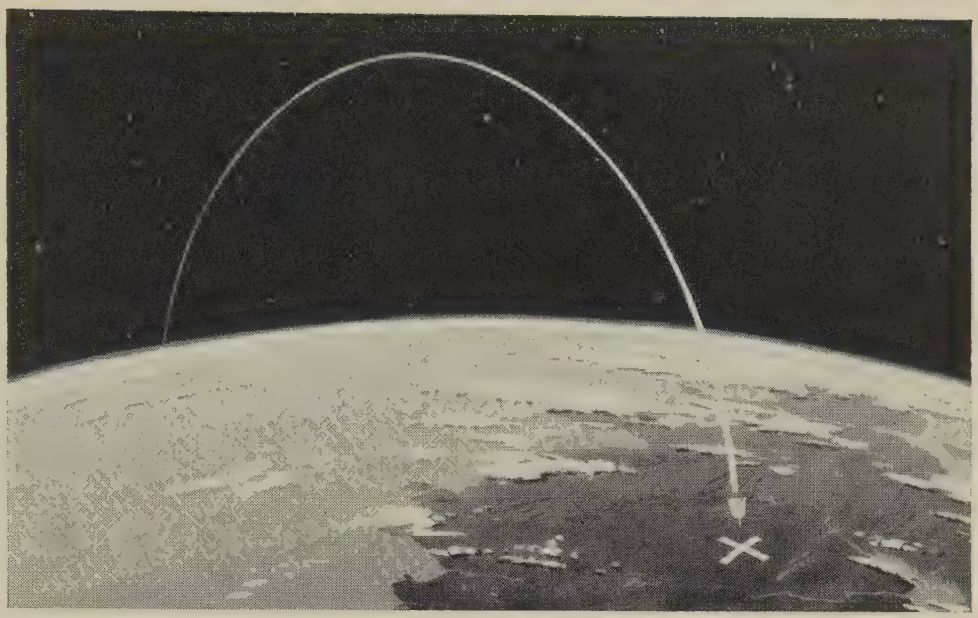
Dr. Oliner feels that one of the privileges associate with conducting research at a university is the opportunit to integrate that research into the teaching curriculum His outstanding ability as a teacher has been sincerel appreciated by his many students. Dr. A. B. Giordanc dean of the graduate school and long time associate of Dr Oliner at MRI, adds, "Art is one of the most meticulou men I know and it shows in his classes. No student ca walk into his class and not know that many painstakin hours went into the preparation."

He has been thesis adviser for many graduate student over the past dozen or so years; among the doctorals hav been Henry Jasik of Jasik Laboratories, Harold Seidel o

(*Continued on page 30*)

Dr. Oliner is shown with automatic recording equipment for the measurement of surface wave and leaky wave antennas.





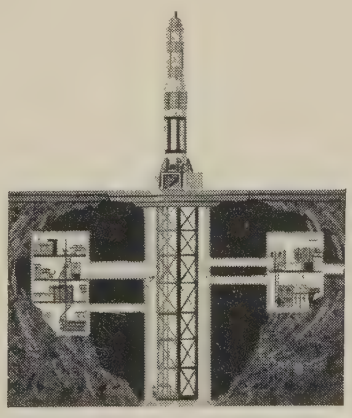
ASSIGNMENT: HIT A TARGET 6000 MILES AWAY

Can you guide a 110-ton Air Force Titan missile far up into the sky, to bring its nuclear warhead down with pinpoint accuracy on a target one-fourth the way around the globe—a target you not only can't see but which continually moves with the spinning earth?

This was the problem in missile guidance the Air Force presented to Bell Telephone Laboratories and its manufacturing partner, Western Electric. The answer was the development of a command guidance system which steers the Titan with a high degree of accuracy.

Unlike self-contained systems which demand complex equipment in the missile itself, Bell Laboratories Command Guidance System keeps its master control equipment on the ground where it can be used over and over again. Thus a minimum of equipment is carried in the missile, and the ground station has full control of the missile during its guided flight. Techniques drawn from the communications art render the system immune to radio jamming.

Bell Laboratories scientists and engineers designed the transmission and switching systems for the world's most versatile telephone network, developed much of our nation's radar, and pioneered in missile systems. From their vast storehouse of knowledge and experience comes the guidance system for the Titan.



BELL TELEPHONE LABORATORIES

World center of communications research and development

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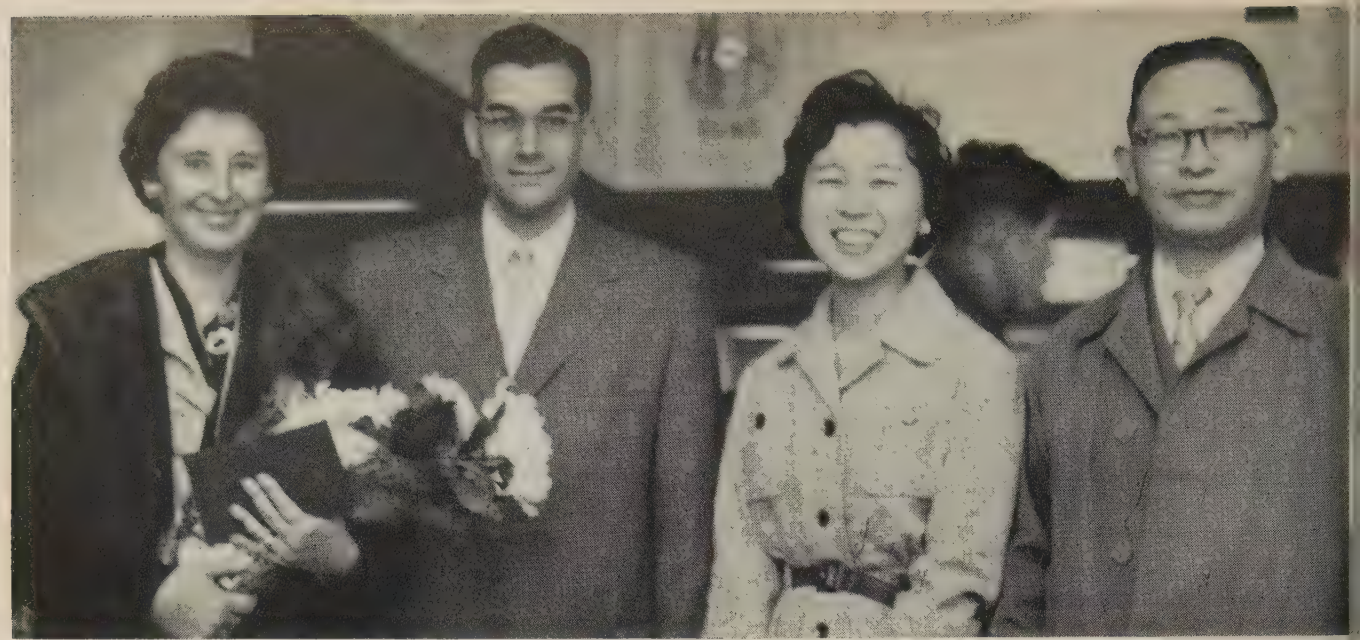


Arriving in Tokyo Airport are (left to right) Mrs. Oliner, Dr. Oliner, Miss M. Morita and Professor K. Morita of Tokyo Institute of Technology.

Dr. Oliner

(*Continued from page 28*)

Bell Labs, and Leonard O. Goldstone, associate professor at the Polytechnic.

A taste for the flavor of industrial interests in the microwave field was obtained during a leave of absence in the summer of 1952, at the Hughes Aircraft Company in California. Since that time he has done industrial consulting in the microwave field for a variety of companies, including Hughes Aircraft Company, Airborne Instruments Laboratory, Raytheon Company, Technical Research Group, Inc., Merrimac Research and Development Company, MIT's Lincoln Laboratory, and IBM.

Dr. Oliner, who looks younger than his 39 years, is perhaps one of the most active young men in the IRE. At present he is Chairman of both the Committee on Antennas and Waveguides and the Professional Group on Microwave Theory and Techniques. Before his election to the Chairmanship of PGMTT he served on its Administrative Committee for four years. During his seven year tenure on the Committee on Antennas and Waveguides, he also served as chairman of the subcommittee that produced the "Standards on Waveguide and Waveguide Component Measurements," published in the April, 1959, issue of the IRE Proceedings.

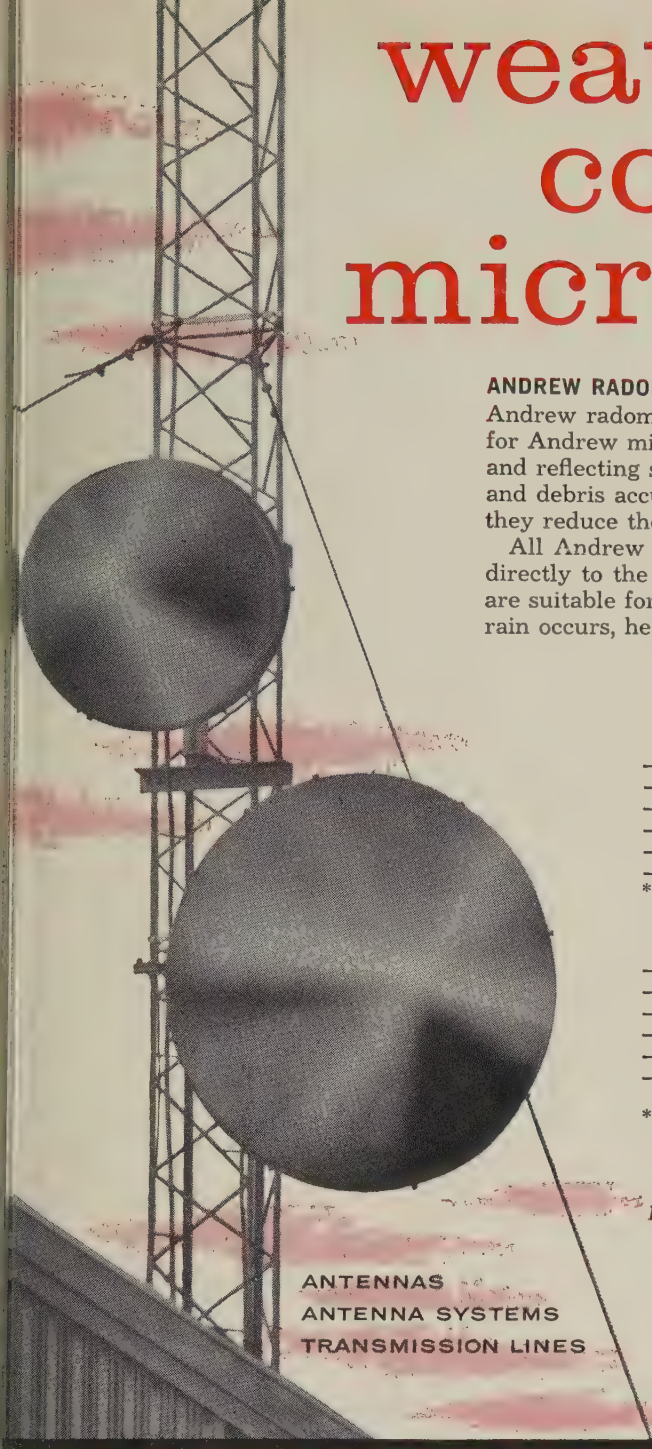
His work with URSI (International Scientific Radio Union) includes membership on Commission 1 (Radio Standards and Measurements) and Commission 6.3 (Antennas and Waveguides). In this capacity he was a United States delegate to the URSI General Assembly meeting held in Boulder, Colorado, in 1957 and will be a U.S. delegate to the forthcoming URSI General Assembly in London. He was also recently elected the Chairman-designate (to become Chairman next year) of U.S.A. Commission 1. In addition, he is a member of the National Academy of Sciences Advisory Panel to the National Bureau of Standards.

Married and the father of two children, Dr. Oliner spends his infrequent "non-professional" moments pursuing interests he developed as a young man; photography, a love of music, and sight-seeing, the latter often a family affair. In connection with the URSI Boulder meeting in 1957, he drove by car to the Rocky Mountains with his wife Frieda and children Marian and Eric, now 12 and 9, respectively.

Perhaps the most exotic family excursion came last fall when Dr. and Mrs. Oliner went to Japan as the guests of three Japanese scientific societies. The occasion for the month-long visit was an invitation by the Institute of Electrical Engineers of Japan, the Institute of Electrical Communication Engineers of Japan, and the Tokyo Section of IRE, for Dr. Oliner to deliver a series of lectures and to visit university, industrial and government laboratories engaged in microwave work. Professor K. Morita of the Tokyo Institute of Technology was instrumental in arranging these invitations and organizing the major aspects of the visits, and Dr. H. Nishio of the Nippon Electric Company made the detailed arrangements and acted as host. The Oliners also spent a week on Taiwan as the guest of the Ministry of Education, where Dr. Oliner delivered lectures and visited several universities, with Dr. S. M. Lee, Vice Minister of Education, acting as their host. In all, Dr. Oliner delivered about a dozen lectures on microwave topics, in the cities of Tokyo, Sendai, Sapporo and Osaka in Japan, and Taipei, Hsinchu and Tainan in Taiwan.

In speaking about his Far East trip aside from its technical aspects, Dr. Oliner calls it "the most memorable and wonderful visit I have ever made." This reaction is in part due to the thrill he received in revisiting a culture familiar to him as a boy, and in part because of the unparalleled opportunity to combine his interest in sightseeing and photography. He purchased a single-lens reflex Nikon camera in Japan, and has presented travelogues of his Far East trip since his return. He stresses, though, that the most memorable feature of the trip was the deep warmth and hospitality that both he and his wife encountered. One of Dr. Oliner's colleagues says, however, "Art doesn't mention the fact that these invitations reflect on the extent of his reputation."

weather conditioned microwave



ANDREW RADOME EQUIPPED ANTENNAS DEFY ICE...SNOW...WIND

Andrew radomes provide excellent 2-way year-round protection for Andrew microwave antenna systems. First, they protect feed and reflecting surface against the attenuating effects of snow, ice and debris accumulation. Secondly, for tower mounted antennas they reduce the effects of wind thrust by 35%.

All Andrew radomes are lightweight and easy to install—clip directly to the dish rim of existing antennas. Unheated radomes are suitable for all but exceptional cases. In areas where freezing rain occurs, heated radomes can be provided.

SPECIFICATIONS

STANDARD RADOMES

Dia. Feet	Type No.	Attenuation @ 6 kmc. db	VSWR Contribution @ 6 kmc	Thrust at* 30 psf (Flats), lbs.
10	R10	0.4	0.02	1,990
8	R8	0.4	0.02	1,270
6	R6	0.4	0.02	714
4	R4	0.4	0.02	320
2	R2	0.4	0.02	75

*Including antenna

HEATED RADOMES

Dia. Feet	Type No.	Attenuation @ 6 kmc. db	VSWR Contribution @ 6 kmc.	Thrust at* 30 psf. (Flats), lbs.	Power** Reqmts.
10	HR10	0.7	0.02	1,990	3,400 watts
8	HR8	0.7	0.02	1,270	2,400 watts
6	HR6	0.7	0.02	714	1,200 watts
4	HR4	0.7	0.02	320	550 watts
2	HR2	0.7	0.02	75	150 watts

*Including antenna

**Power requirements for HR10 and HR8 are 3 wire single phase 60 cycle 220 volts.

Power requirements for HR6, HR4 and HR2 are single phase 60 cycle 115 v.

For further details on ANDREW Microwave Antennas, Radomes, Wave Guides write for new Andrew Catalog M.

ANTENNAS
ANTENNA SYSTEMS
TRANSMISSION LINES

ANDREW

Andrew CORPORATION

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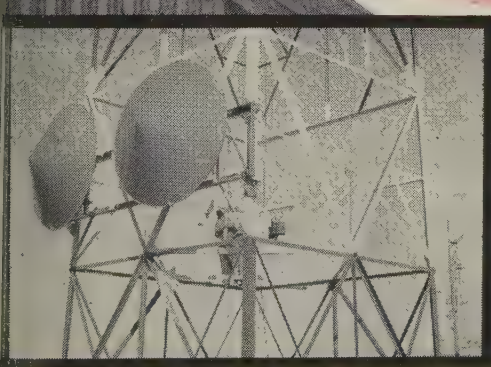
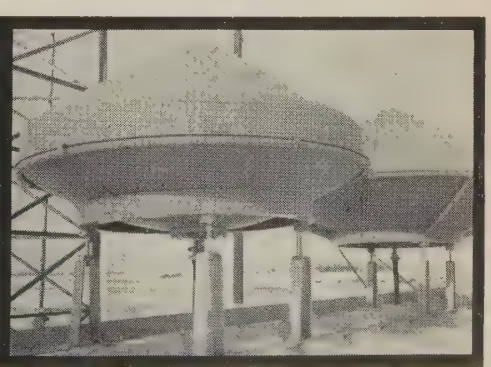
Boston • New York • Washington • Los Angeles • Toronto



"We have paid particular attention to antennas during high wind conditions of gusts up to 40-60 m.p.h. It is very obvious that these radomes quite materially reduce the wind loading on the parabolas—due to their shape factor." *Washington State Patrol, Kennewick, Washington*

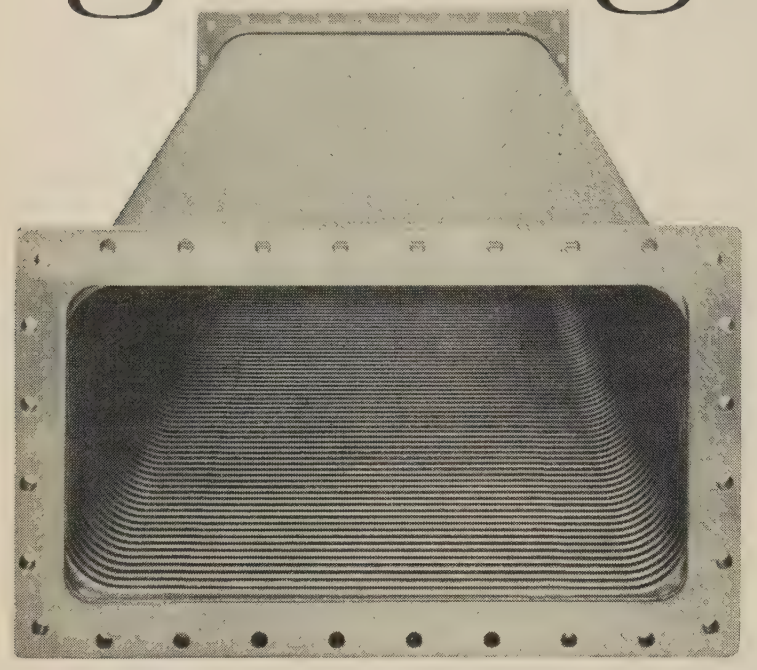
"We have had up to four inches of ice on the radome with practically no reduction of antenna effectiveness." *KLIX-AM-TV, The KLIX Corporation, Twin Falls, Idaho*



"Our field forces report that the radomes produce a signal loss of less than 1 db per antenna. Several radomes were removed and antennas inspected following a heavy snow storm and no snow or ice was found in the antennas." *Natural Gas Pipeline Company of America*

Circle Reader Service Card 23

guiding



APPROX. 1/6 SCALE

light

WITH A CROSS SECTION OF 10½ BY 21 INCHES, this is the largest and lightest-weight waveguide ever made. The all-aluminum construction significantly reduces weight, as well as the possibility of corrosion. Other important advantages: high temperature applications up to 700° F.—low VSWR and attenuation characteristics—and the ability to handle extremely high power (designed for several hundred KW of average power and over a hundred megawatts of peak power). Airtron aluminum flexible waveguides are available in a number of sizes from WR-90 to WR-2100. Write for additional facts.

AIRTRON

A DIVISION OF LITTON INDUSTRIES

AIRTRON-LINDEN • 1301 EAST LINDEN AVENUE, LINDEN, NEW JERSEY
GENERAL OFFICES, MORRIS PLAINS, NEW JERSEY

Industry News

(*Continued from page 22*)

ARTHUR J. WILDE ELECTED PRESIDENT OF NAECON FOR 1961

Arthur J. Wilde of Motorola Inc., Phoenix, Arizona, has been elected president of the National Aeronautical Electronics Conference (NAECON) for 1961.

Manager of the Regional Representatives Office at Dayton for the Motorola Military Electronics Division, Mr. Wilde is the first industry member in the 12 year history of NAECON to be elected to the highest office.

Mr. Wilde, a Colonel in the USAFR, served with the Air Force during World War II and later held various technical administrative positions at Wright Field and Elgin Air Force Base.

Joining Motorola in 1955 as assistant chief engineer of the Defense Department in Chicago, he ultimately went to Dayton as manager of the Regional Office for the Military Electronics Division.

He is active in Dayton civic affairs, a president of the Reserve Officers Association and a member of the Board of Governors of Ohio State Honorary Dormitories.

— *mwj* —

CONWAY AND KNUDSEN JOIN SPACE ELECTRONICS CORP.

Space Electronics Corporation, Glendale, Calif., has announced the addition of two members to its technical staff.

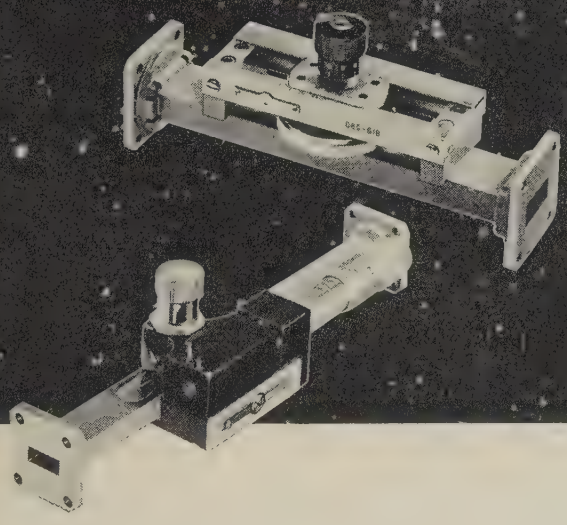
William H. Conway joins the firm from Ramo Wooldridge Corporation, having previously served with the Bell Telephone Laboratories and the University of Illinois. A graduate in electrical engineering from the University of Illinois, he is a member of the IRE and Eta Kappa Nu.

Arnold C. Knudsen joins the SEC staff from the International Telephone & Telegraph Laboratories. He is a graduate of the University of California in electrical engineering and a member of Tau Beta Pi and Eta Kappa Nu.

— *mwj* —

(*Continued on page 34*)

what is the frequency standard for the U.S.A.?



ANSWER: By act of Congress, the U.S. Bureau of Standards determines the primary standard, based on the revolution of the earth. All DeMornay-Bonardi microwave instruments are calibrated at frequencies which are verified by our secondary standard, which, in turn, is periodically calibrated, point for point, by the U.S. Bureau of Standards.

One way to properly match a microwave transmission line is by using a D-B Stub Tuner to reduce mismatch losses and utilize the total energy available.

D-B stub tuners in the 2.6 to 18 KMC range have a new scale and vernier that gives precise resettability in longitudinal travel. A new micrometer scale on the probe measures penetration with very high accuracy.

Probe wobble is eliminated, and no resonances can occur under any conditions. You can correct VSWR as high as 20:1 with amazing accuracy (1.02). You can tune with precision... reset to original settings with certainty that phase and magnitude have been duplicated.

Ditto for higher frequencies. D-B tuners in the 18 to 90 KMC range are not simply scaled-down units—they're engineered for ultramicrowave® use. All the above features are available, plus micrometer positioning which provides readability to .0001".

Write for data sheets—they detail all features, applications, dimensions, sizes. Bulletin DB-919.

DE MORNAY BONARDI®

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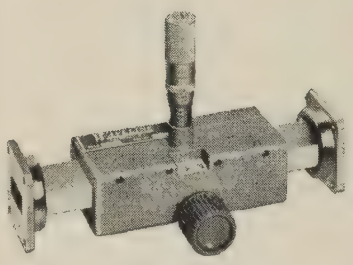
WAVELINE

PRECISION MICROWAVE INSTRUMENTS

WR-51 TEST EQUIPMENT

PRECISION COUPLERS
VARIABLE ATTENUATORS
VARIABLE SCREW TUNERS
TERMINATIONS
- HIGH POWER
- LOW POWER
- SLIDING

ADJUSTABLE SHORTS
TRANSITIONS
SHORTING SWITCHES
ELBOWS and TWISTS



X-BAND WAVEGUIDE SWITCH

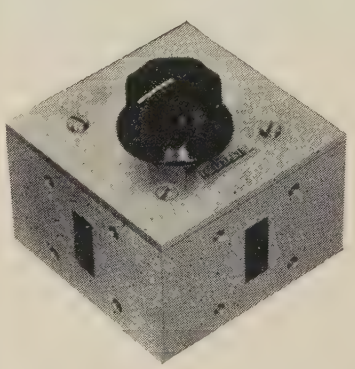
Model No. 678-E

This unit is a manually operated four port waveguide switch for use over the full range of 8.2 to 12.4 Kmc. This precision X-band has been designed for laboratory use or for systems application to make alternate connections between two waveguide inputs and two waveguide outputs.

Characteristics:

VSWR of less than 1.05
Isolation greater than 45 db.
Attenuation negligible

An "H" plane version of this switch is also available as Waveline Model No. 678-H.



WAVELINE INC.

CALDWELL, NEW JERSEY

Phone CApital 6-9100 TWX Caldwell, N. J. 703

Industry News

(*Continued from page 32*)

CANFIELD NAMED PHILCO RESEARCH MARKETING MANAGER

The new post of marketing manager for Research Division has been filled by Edward F. Canfield, according to an announcement by Philco Corporation, Philadelphia, Pa.

Responsibilities in the new task include planning, coordination and field activities in the Research Division's contacts with the Armed Forces and with industrial clients.

Mr. Canfield is a graduate of St. Joseph's College, Philadelphia and the University of Pennsylvania Law School. His memberships include Philadelphia Bar Association, Gladwyne Civic Association and the American Legion.

Veteran of World War II and of the Korean conflict, Mr. Canfield holds the rank of Lieutenant Commander in the USNR.

— *m w j* —

SEVENTH ANNUAL PGNS MEETING

The Seventh Annual Meeting of the Professional Group on Nuclear Science of the IRE is to be held in Gatlinburg, Tennessee on Oct. 3, 4 and 5, 1960. The meeting, jointly sponsored by PGNS and Oak Ridge National Laboratory, will feature papers on Solid State Radiation Detectors and low noise amplifiers and their applications to nuclear science. Exhibits, appropriate to the meeting theme, will be on display and a tour of the ORNL "Project Sherwood" Thermonuclear Facilities will be available to those interested.

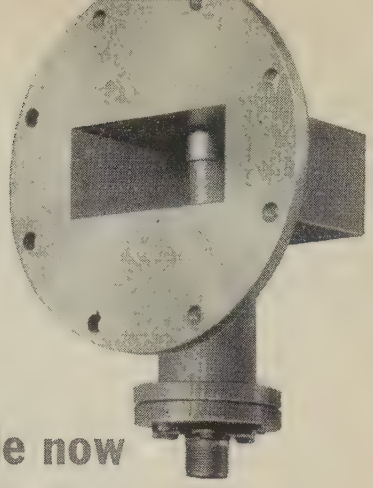
Papers appropriate to the above theme are solicited. Please send by August 1, 1960, the title and about fifty words of description to:
H. E. Banta, Oak Ridge National Laboratory, P.O. Box "X", Oak Ridge, Tennessee.

Information concerning the meeting may also be obtained from Dr. Banta.

— *m w j* —

(*Continued on page 36*)

SMALL APPETITE NOISE SOURCES



service-proved and available now

Until recently signal simulators for monitoring radar receivers or microwave relays were of two types. One was a big and heavy ampere eater with cumbersome auxiliary equipment; and the other was a sensitive though delicate instrument suitable only for the laboratory.

We call your attention now to the Litton 2000 series of miniature gas noise sources. The Litton 2000 for waveguide use is pictured above. It has a first cousin, the Litton 2007 designed for coaxial cable use. We call your attention because most tubes in this series are now in production and we suspect there are frustrated design engineers who will receive this announcement with keen interest.

Our gas noise sources may properly be called miniature. They require only inches of space, smaller, lighter auxiliary equipment, and small voltages and currents. Around 500 volts fires them; 100 milliamperes maintains them. These characteristics, plus others, have caused them to find numerous applications: for in-flight calibration and test of aircraft microwave receivers; as *automatic* watchdogs on airborne radar systems; and in other systems which require various immunities to vibration, shock, humidity, and temperature cycling.

The Litton family of miniature gas noise sources, like all Electron Tube Division products, was designed to solve specific end item functions. We have found that this philosophy contributes to consistent reliability: tubes do their jobs more efficiently, for longer periods of time, and at lower overall cost to the buyer. Other advantages also result. For example, these noise sources require *no* ageing-in and the L-2000 is replaceable in the field without changing the mount.

Specific frequency ranges in L, S, C, X and K bands are covered. If you are concerned with radar transmission, or with microwave data links of any kind, we'll gladly send you more information. Write to Litton Industries Electron Tube Division, Office M14, 960 Industrial Road, San Carlos, Calif.

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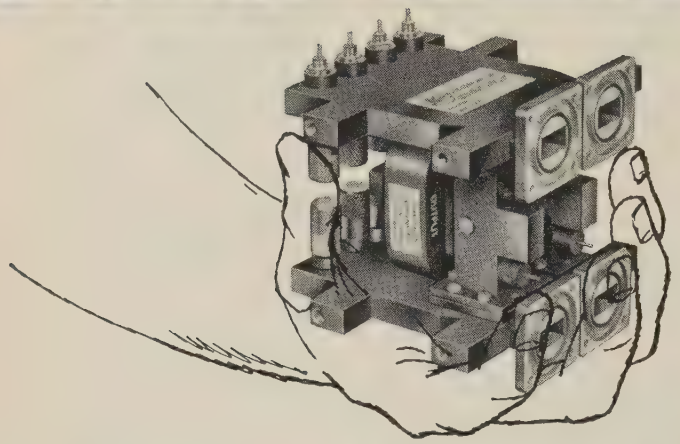
LITTON INDUSTRIES Electron Tube Division

BARRATRON® TRANSMITTING TUBES • MAGNETRONS • KLYSTRONS • TRAVELING WAVE TUBES • BACKWARD WAVE OSCILLATORS • GAS DISCHARGE TUBES • NOISE SOURCES • CROSSED-FIELD AMPLIFIERS • HIGH DEFINITION CRT DIRECT-WRITING CRT • COLOR CRT • STORAGE TUBES • MICROWAVE FILTERS • DUPLEXERS • TR TUBES

PACKAGED PRECISION
for your exact requirements



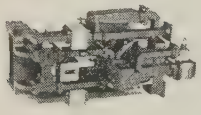
MICROWAVE Kearfott PRODUCTS

MICROWAVE SUB-SYSTEMS

Mono-Pulse Radar

S-Band Strip-transmission Head

Mixer Duplexer



High Power Mixer Duplexer

Kearfott has the experience and ability to design precision sub-systems to the customer's actual configuration and performance needs. The availability of a wide variety of standard components, coupled with advanced techniques, makes it possible to provide packaged r-f assemblies with a high component density—tailored to precise volumetric specifications. For minimum size and weight in airborne or missile applications—for military system environment—Kearfott will successfully design *your* sub-system—to *your* most exacting requirement.

Inquiries may be directed to: 14844 Oxnard Street, Van Nuys, California

KEARFOTT DIVISION

GENERAL PRECISION INC.

LITTLE FALLS, NEW JERSEY

Circle Reader Service Card 28

Industry News

(*Continued from page 34*)

COMBELLICK APPOINTED BY LENKURT CO.

Thomas A. Combellick, formerly chief engineer for Military Products Development, has been appointed Government Marketing Manager for Lenkurt Electric Co., Inc., San Carlos, Calif.

Norman N. Epstein succeeds Combellick as chief engineer for Military Development at the telecommunications firm, a subsidiary of General Telephone & Electronics Corp.

Combellick joined Lenkurt in 1955 as a project engineer and during the next two years served as manager of several development and applications engineering departments.

In November, 1957, he was appointed manager of the company's Washington, D.C., sales and engineering offices, with responsibility for customer relations in the eastern U.S. He returned to San Carlos and the chief engineer position in March, 1959.

Before joining Lenkurt, Combellick spent five years with Westinghouse, where he was in charge of microwave system development, and five years with Western Electric, where he was project engineer on the manufacture and test of tubes for the TD-2 microwave system.

Combellick was graduated from Hampden Sydney College, Va., with the BS degree, and pursued postgraduate studies at the Harvard Graduate School of Engineering and at Massachusetts Institute of Technology.

He is a member of the AIEE and the Armed Forces Communications and Electronics Association, and a senior member of the IRE. He is the author of several papers on microwave radio subjects.

Epstein has been with Lenkurt since 1950 in technical and engineering management positions of increasing responsibility. In 1954, he was appointed project engineer, and in 1956 was named manager of Carrier Development Dept.

In July, 1958, Epstein was appointed to the Military Engineering group as project manager in charge of developing the AN/FCC-17, fully transistorized 600-channel multiplex system for the U.S. Air Force. He has led this project until his recent promotion to chief engineer, Military Development.

Epstein has BSEE and MBA degrees from the University of California. He is the author of papers on multiplex and microwave radio developments, and holds several patents in these fields.

—*mwj*—

(*Continued on page 38*)

Circle Reader Service Card 29

Gabriel pioneers new ideas in antenna feeds and horns

Since the days when "Radar" was classified to present ultra-long-range space probings . . . Gabriel precision designed feeds and horns have been specified whenever tolerances and specifications were tight. In one of the first independent antenna research laboratories in the country, Gabriel pioneered in the development of sophisticated antenna feeds and horns.

Notable Gabriel contributions to advancement in the state-of-the-art include the use of high power, dual frequency and dual polarized feeds for radio astronomy and scatter communications . . . slotted feed systems up to six feet at Ka band . . . development of the first Infrared Deicer for large horn feed radomes used in the Dew, Pine Tree, and Aleutian Lines . . . study of Cassegrainian feeds for scatter and monopulse systems . . . and study of new feeds for systems using parametric amplifiers and masers. Write for specifications on the complete line of Gabriel horns and feeds.

New, circularly-linearly polarized, remote controlled feed horn for ASR-4 Airport Surveillance Radar Antenna provides excellent ICR to reduce out-of-phase signals from precipitation, dust and sea return.

Gabriel electronics DIVISION OF THE GABRIEL CO., MILLIS, MASS.

PIONEERS IN ANTRONICS

AIRPORT SURVEILLANCE RADAR ANTENNAS

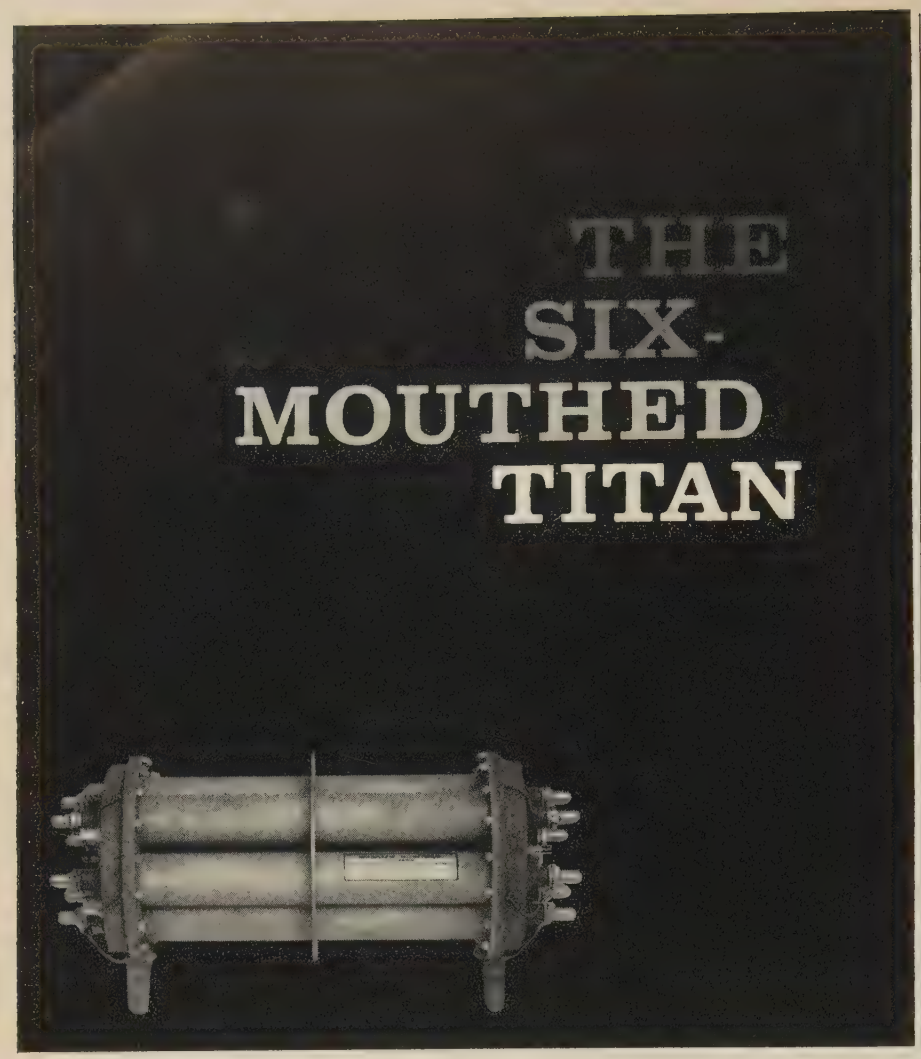
ROTARY JOINTS

POINT-TO-POINT COMMUNICATION ANTENNAS

FEEDS AND HORNS

DRONE & DRONE CONTROL ANTENNAS

RESEARCH & DEVELOPMENT



In flight, The Martin Company's highly reliable Titan transmits an immense amount of telemetry data. Yet, with Rantec multiplexers, it avoids the weight and space problems of a complex antenna system. It is now easily possible to couple two, three, four or six telemetry signals of slightly different frequencies to one antenna system. This is done with minimum insertion loss and maximum isolation (the six channel model illustrated has a minimum isolation between channels of 20db and a maximum insertion loss of 1.5db). Rantec multiplexers, as utilized in Martin's Titan, are another example of Rantec's adaptation of highly-sophisticated R&D to the design and manufacture of reliable, state of the art hardware. Technical data and reprints are available upon request.

rantec

corporation

calabasas, california

Circle Reader Service Card 30

Industry News

(*Continued from page 36*)

SPACE ELECTRONICS AND TELEMETRY 1960 NATIONAL SYMPOSIUM

The Professional Group on Space Electronics and Telemetry will sponsor the fifth National Symposium concerning this technological field at the Shoreham Hotel in the nation's capitol on Sept. 19, 20 and 21. This year's Symposium will emphasize discussion of new design philosophies and advances in the state-of-the-art.

The program is organized around 11 panel type sessions, each directed by a chairman prominent in the particular technical field. The panelists and the subject of their papers are selected by the panel chairman, thereby assuring stimulating content and coherency to each panel area. It is planned to pre-publish the panelists' papers in the Symposium Proceedings and limit paper presentations to their highlights in order to insure sufficient time for inter-panel discussion, questions and audience participation.

The program includes social events such as the PGSET banquet, cocktail parties, luncheon, hospitality room and ladies activities. There will also be a large and varied industrial exhibition.

— *m w j* —

ASSOCIATE DIRECTOR OF MICROWAVE RESEARCH INSTITUTE ELECTED TO BOARD OF COLUMBIA TECHNICAL CORP.

Dr. Herbert J. Carlin, associate director and research professor of electrical engineering at the Microwave Research Institute of Polytechnic Institute, Brooklyn, N.Y., has been elected to the board of directors of Columbia Technical Corporation, Woodside, N.Y., manufacturers of electronic components, it was announced by Dr. Nikit Ordjanian, president of the company.

Dr. Carlin holds a masters in electrical engineering from Columbia University and a doctorate in electrical engineering from Polytechnic Institute of Brooklyn. From 1945 to 1959 he taught graduate courses at the Microwave Research Institute in network and electromagnetic theory. From 1950 to 1952 he was chairman of the National Network Technical Committee of the AIEE and in 1952 and 1953 he was chairman of the Basic Science Division of the New York section of the AIEE. From 1955 through 1956 he was chairman of the Professional Group on Circuit Theory of the IRE and a member since 1954 of the Technical Papers Review Committee of the IRE. He presently holds 10 patents in the field of network theory and microwave techniques.

— *m w j* —

(*Continued on page 64*)

IX VSWR AMPLIFIER FEATURES

...available only from NARDA

1. Battery-operated (rechargeable nickel-cadmium).
2. Completely transistorized for low current drain.
3. Independent of line voltage variations.
4. Complete bolometer protection during switching.
5. Most compact unit available.
6. Completely portable.

Model 441B—$225

w you can get a completely portable battery-erated VSWR Amplifier offering complete protec-n against bolometer burnout at the same time!

rda's Model 441B is supplied with nickel-cadmium tteries, providing complete freedom from line tage deviations. Batteries recharge automatically en unit is plugged in; provision is built-in to show te of battery charge. A special protective circuit permits switching and connect-disconnect with no danger of bolometer burnout. Provision is made for both crystals and high **and** low current bolometers.

Full sensitivity is provided over both normal and expanded scales; eliminates switching attenuation range. Other features are shown on this page; for complete information and a free copy of our latest catalog, write to us at: Department MJ-10.

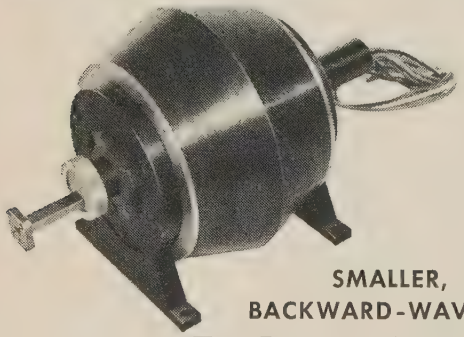
EATURES:

SENSITIVITY:	0.1 microvolts at 200 ohms for full scale.
FREQUENCY:	1,000 cps ± 1% (plug-in frequency networks available for 315-4,000 cps and broad-band applications)
BANDWIDTH:	25-30 cps
RANGE:	72 db (60 db in 10 db steps, 11 db continuous)
ACCURACY:	± 0.1 db per step • ± 0.2 db maximum cumulative • meter linearity: 1% of full scale

the narda microwave corporation

118-160 HERRICKS ROAD, MINEOLA, L. I., N. Y. • PIONEER 6-4650

Millimeter devices now available in six product lines



SMALLER, LIGHTER BACKWARD-WAVE OSCILLATOR

Type BW-1757 delivers up to 15 mw from 26.5-41 kmc in a streamlined new package. Also available are types from 18 to 26.5 and 40 to 75 kmc. BWO's above 75-100 kmc are in development.

FERRITE CIRCULATORS AND ISOLATORS

In production at Sylvania are Tee circulators and waveguide isolators in the 18 to 26 kilomegacycle range. Development programs are under way for devices above 26 kmc.

MAGNETRONS DELIVERING UP TO 100 KILOWATTS

Sylvania's line of rugged Ka-band magnetrons have output powers from 20 to 100 kw. K-band type M-4154 delivers 55 kw. Samples are available of new, rugged Ka-band type M-4218, weighing only 4½ pounds. Techniques are available for development of types to 100 kilomegacycles.

NEW WAVEGUIDE WINDOWS AVAILABLE

Sylvania is now producing two new waveguide windows in K and Ka bands, with flanged mica windows:

Type WG-4224	18 to 26 KMC
Type WG-4223	26 to 40 KMC

SYLVANIA TR AND ATR TUBES

Sylvania-developed TR and ATR tubes for Ka-band operation are available with power handling capability up to 100 kw.

IN THE DEVELOPMENTAL STAGE:

Sylvania has proved research and development capability for O and M type devices. One of the important projects now programmed at Sylvania's Bayside Physics Laboratory is a harmonic generator in the 200 to 400 kmc range which takes advantage of the non-linear conductivity characteristics of Germanium. And the Bayside labs are at work on the Tornadotron, with which 0.1 MM will be reached; millimeter amplifiers are also in development.

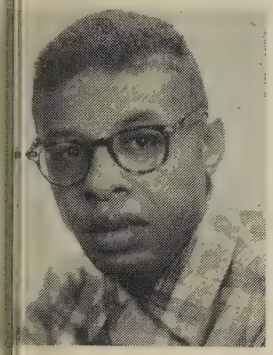
For further information write Sylvania Special Tube Operations, 500 Evelyn Ave., Mountain View, California, indicating the product lines in which you are interested.

SYLVANIA

Subsidiary of GENERAL TELEPHONE & ELECTRONICS

GENERAL SYSTEM

CONTRIBUTORS IN THIS ISSUE

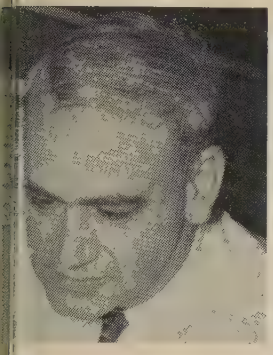


JOHN L. CARTER was born April 6, 1920, in Bramwell, W. Va. He received the BS degree in mathematics and physics from West Virginia State College in 1947, and did graduate work in physics at New York University from 1947 to 1949.

Mr. Carter joined the U.S. Army Signal Research and Development Laboratory, Fort Monmouth, N.J., in 1949.

He is presently a project engineer in the Switching Devices Section of the Microwave Tubes Branch, Electron Tubes Division, engaged in research and development of microwave gas discharge and ferrite duplexing components and associated devices.

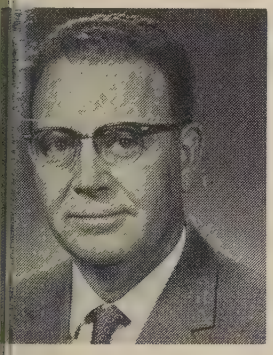
Mr. Carter holds several patents and is the author of several technical papers.



C. LOUIS CUCCIA received his BS and MS degrees in electrical engineering from the University of Michigan and did graduate work in physics at Princeton University.

In 1942 Mr. Cuccia joined the technical staff of the RCA Laboratories where he co-developed the first 2J41 magnetron, did research and development on frequency-modulated and frequency-locked magnetrons and on transverse-field traveling-wave devices known as "Electron Couplers," and co-developed the first coaxial microwave low-pass filters. In 1952, he authored the McGraw-Hill book, "Harmonics, Sidebands and Transients in Communication Engineering," and has written many technical papers.

In 1957, he joined RCA Microwave Operations as engineering leader in charge of traveling-wave tube and backward-wave-oscillator development, and in 1959 to the present has been responsible for the product development of solid-state microwave systems and related microwave-tube systems.

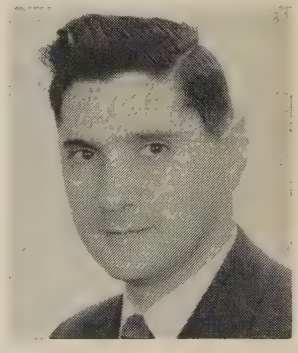


RAYMOND E. GLASS received a BS degree in electrical engineering from Texas Technological College in 1940 and received his MS degree in EE in 1942. Later, he held a graduate assistantship at Illinois Institute of Technology.

After graduation, Mr. Glass was a junior engineer with the Westinghouse Radio Division, participated in their Engineering Training Program, and taught electronics for the Pre-Radar and Army Specialized Training Programs at Texas Tech.

From 1944 to 1946 he worked on omni-range, audio and FM home radio equipment for the Bendix Radio Division. From 1947 to 1949 Mr. Glass was a senior engineer with the Glenn L. Martin Co., where he worked on antennas and microwave plumbing equipment for aircraft radar.

Since 1949 he has been with the Sandia Corporation, Albuquerque, N.M., as a staff member and section supervisor of the Telemetering Systems Division, Instrumentation Development Department, Field Testing.



RRIS KATZMAN was born in New York City on October 2, 1923. He received BS degree in physics in 1949 and his MS degree in physics in 1955, both at New rk University. In 1951 Mr. Katzman joined the U.S. Army Signal Research and velopment Laboratory, Fort Monmouth, N.J., where he worked on meteorological sing devices and on semiconductor devices. In 1957 he joined the Electron Tubes vision, and is presently chief of the Atomic Resonance Devices Section of the crowave Tubes Branch.

WING REINGOLD received his BS degree in engineering in 1942 and the engineer's degree in 1949, both from the Newark College of Engineering. He has done aduate work in electronics at the Brooklyn Polytechnic Institute and is a licensed ofessional engineer in the state of New Jersey. From 1943 to 1945 Mr. Reingold s an electronics manufacturing engineer at Westinghouse Electric Company, omfield, N.J. From 1945 to 1951 he was a project engineer in the Radar Branch the Watson Laboratories, Air Material Command, Red Bank, N.J. Mr. Reingold ned the Electron Tubes Division of the U.S. Army Signal Research and Development Laboratory, Fort Monmouth, N.J., in 1951, and is presently chief of the itching Devices Section of the Microwave Tubes Branch. Mr. Reingold is the der of several patents and has authored a number of technical papers in the crowave duplexer and ferrite fields. He is also a senior member, the IRE.

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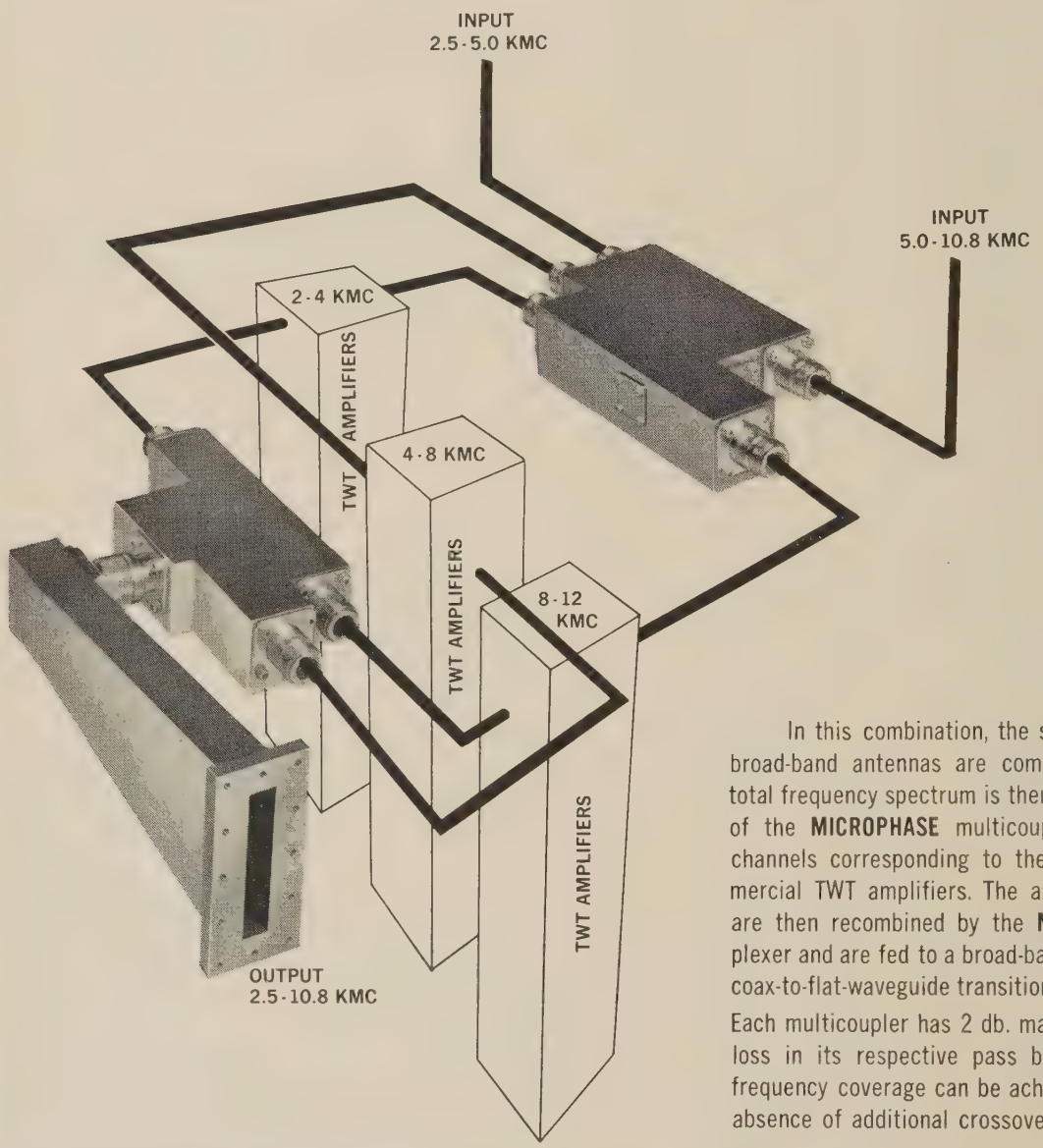

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THE USE OF AN X-BAND SOLID-STATE RUBY MASER WITH A CONVENTIONAL DUPLEXING SYSTEM

JOHN L. CARTER
MORRIS KATZMAN
IRVING REINGOLD

U.S. ARMY SIGNAL RESEARCH AND DEVELOPMENT LABORATORY
Fort Monmouth • New Jersey

Introduction

Although the principal application of masers appears be in the field of radioastronomy, radar systems engin-rs are considering the incorporation of masers in radar ceivers. Equipments most readily adaptable in this anner are those operating at frequencies for which a rametric amplifier has not yet been successfully devel-ed.

In many radar applications optimum use cannot be ade of the maser low-noise characteristics because of the latively "hot" antenna and transmission line compon-ts. Furthermore, the maser gain deteriorates at very w incoming signal levels (lower than the leakage limits ecified for conventional duplexer tubes). This deteriora-on is caused by a "strong" signal at the amplifying fre-ency which reduces the population inversion and hence e gain. If the incoming signal level is of sufficient mag-tude to saturate the maser, the device does not recover om this saturation for a period of time equal to the lat-e relaxation time, which may be several tenths of a sec-d. Nevertheless, predictions have been made that radar stem performance will be enhanced by the use of a maser.

A series of experiments were performed in order to termine the effectiveness of the device when used with conventional radar system. An X-band, solid-state, three-vel ruby maser was evaluated with several types of X-nd duplexer tubes. The experiments simulated an actual dar system application in which a single antenna is used r both transmitting and receiving.

Description

Maser

The ruby maser[1] operates at a signal frequency of 9.3 kmc with a pump frequency of 24 kmc. (A block diagram of the ruby maser is shown in Figure 1, and an artist's sketch is shown in Figure 2.) The device has a doubly-resonant rectangular cavity, resonant in the TE_{012} mode at K-band and in the TE_{011} mode at X-band. Coupling from the transmission line to the cavity is accomplished by a waveguide transition. The transition tapers from the standard X-band waveguide size to the K-band

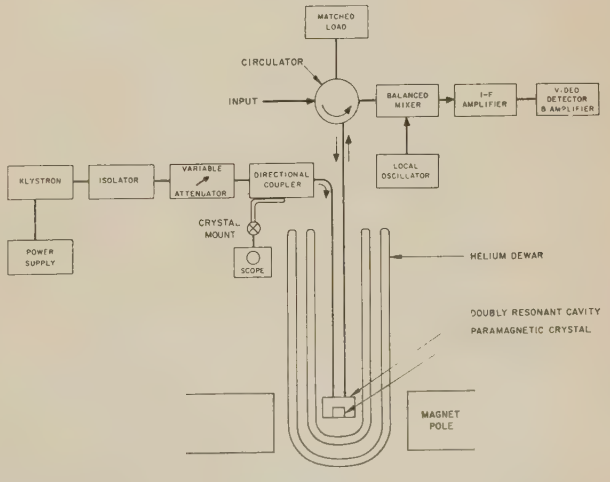


Figure 1 — Block diagram of ruby maser.

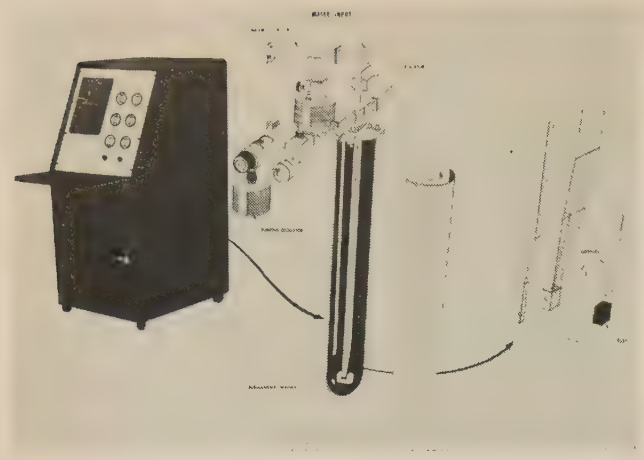


Figure 2 — Artist's sketch of ruby maser.

dimensions of the cavity. A piece of clear sapphire in the transition keeps the waveguide above cutoff. An iris window couples the transition section to the cavity. The transition design takes advantage of the small cavity dimensions, permitting the use of a twelve-ounce magnet to supply the required field of 4000 gauss. The entire maser preamplifier, including cryostat, magnet, and associated microwave plumbing, weighs twenty-five pounds and occupies one-third cubic foot of space. The gain-bandwidth product is about 100 mc at 4.2°K. The total effective noise temperature, including input losses, noise temperature of the maser crystal, and a receiver with an 8-db noise figure, is approximately 30°K.

Amplification of the three-level maser occurs in the following manner: Under the influence of a cw pump signal, energy level ϵ_1 is coupled with energy level ϵ_3, thus equalizing the populations of these two levels. Energy level ϵ_2 remains unchanged during this process, and is over populated with respect to ϵ_1. The over-population of a higher energy level over a lower energy level create an emissive condition. The application of rf energy (th signal to be amplified) at a frequency appropriate to th energy difference between levels ϵ_2 and ϵ_1 causes a ne emission of energy, since the high energy state is mor heavily populated. In this way the input signal is en hanced, and amplification occurs.

If the input signal level is too high, a large number o spins will drop from level ϵ_2 to ϵ_1. As a result, the popula tions of these two levels become equal, and saturation oc curs. Thus, the emissive condition is destroyed, and n amplification takes place. When the high-level input signa is removed, the influence of the pump will re-establish th emissive condition required for signal amplification. A finite time, known as the recovery time, is required fo this condition to occur once saturation has taken place. I the emissive condition is partly destroyed, partial saturatio occurs, resulting in a deterioration of the maser gain cha acteristics.

TR Tubes

Two types of TR tubes, a 1B63A and a 6334 du tube, were used in the experiments. The former is used i branched duplexers, and the latter (with a pair of 3-d hybrid couplers), is used in balanced duplexers.

Leakage through a gas-discharge TR tube generally con sists of two parts, the spike and the flat. Spike leakag energy is that contained in the initial portion of the puls before the establishment of the steady-state discharge. is of short duration (approximately 10^{-8} seconds). Fl leakage power is that remaining when the spike portio is subtracted from the total leakage.[2]

The leakage through the 1B63A tube was primaril spike, while the leakage through the 6334 tube was mainl flat. Experiments were also made using a flat leakage puls through a directional coupler with no TR tubes in th transmission line.

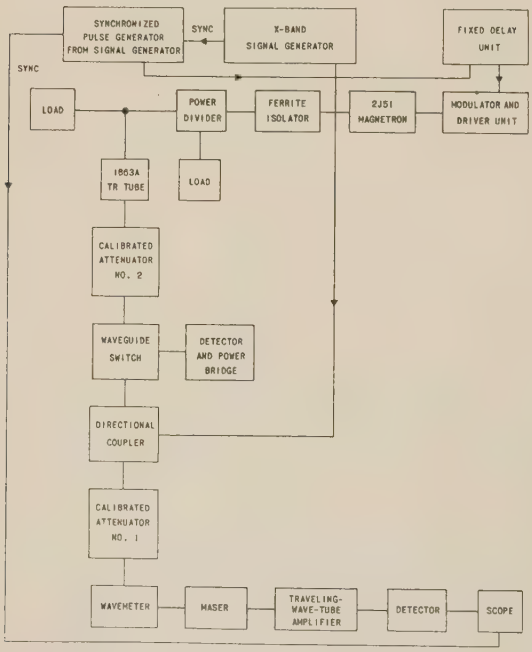


Figure 3 — Block diagram of leakage measurement set-up with Type 1B63A TR tube.

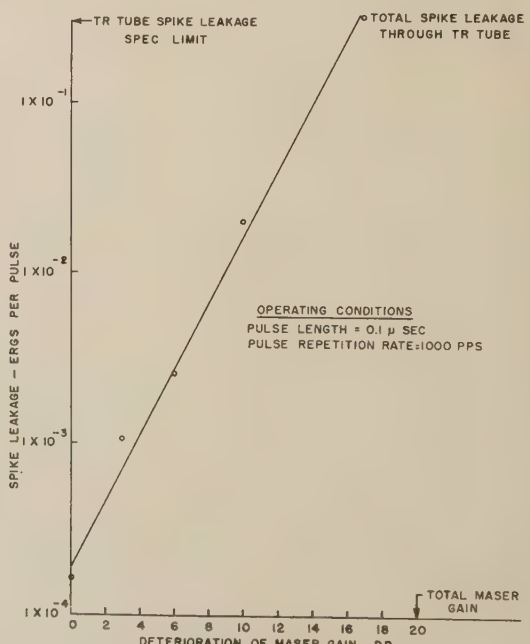

TR TUBE SPIKE LEAKAGE SPEC LIMIT
TOTAL SPIKE LEAKAGE THROUGH TR TUBE
OPERATING CONDITIONS
PULSE LENGTH = 0.1 μ SEC
PULSE REPETITION RATE=1000 PPS
SPIKE LEAKAGE - ERGS PER PULSE
1 X 10⁻¹
1 X 10⁻²
1 X 10⁻³
1 X 10⁻⁴
TOTAL MASER GAIN
0 2 4 6 8 10 12 14 16 18 20
DETERIORATION OF MASER GAIN - DB

Figure 4 — Effect of spike leakage on maser gain — Typ 1B63A TR tube.

perimental Procedure

Leakage through the two TR tube structures and the ectional coupler was measured using conventional techues. Data were taken at a pulse repetition rate of 1000 s and at pulse lengths of 1.0 and 0.1 usec. The leakage the 0.1-usec pulse was essentially all spike leakage.

A typical arrangement of test equipment for these meements is shown in Figure 3. A calibrated attenuator s used to control the magnitude of the leakage signal r a range of full leakage through the duplexer to a ue reducible by 40 db. The waveguide switch transred the leakage signal from the maser input channel to power-measuring bridge channel, permitting direct and urate measurements of the leakage power.

Conventional techniques were used to measure the reery time of the maser after it had been fully saturated. wever, a "one-shot" manually-controlled trigger unit s required in making this measurement. The repetition e for this test was actually one to two pulses per second.

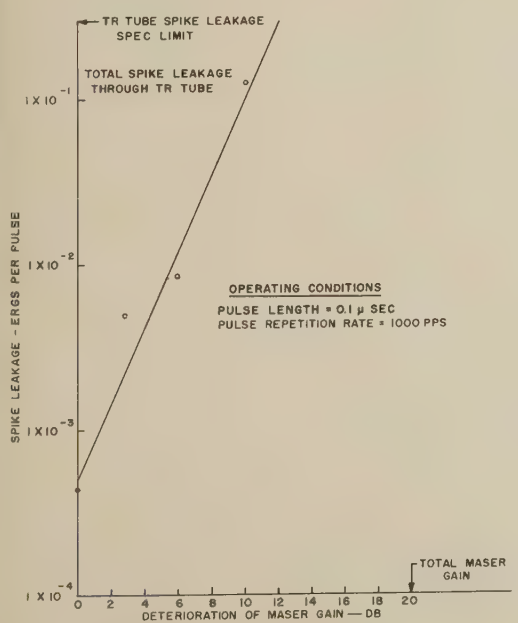
sults

Results of the measurements to determine the signal els at which maser deterioration occurs are shown in ures 4 through 8; results of the recovery time test are wn in Figure 9. These results indicate that the flat kage power, as expected, has more of an effect on the erioration of the maser gain than does the spike leak. The results also show that while deterioration starts extremely low signal levels, complete saturation does occur until the signal level has been increased by sevl orders of magnitude. Once complete saturation ocs, the full recovery time of the maser is approximately sec.

nclusions and Discussion

The experiments lead to the expected conclusion that nventional duplexers cannot adequately prevent deadation of maser performance. However, some improvement may be realized in system performance under certain operational conditions. Full maser saturation can be avoided, and the gain remaining can be useful. The results also indicate the degree of improvement required of the duplexer for full utilization of maser gain characteristics. For optimum use of these characteristics, the leakage through the duplexer cannot be more than 10^{-9} watt.

The duplexer insertion loss and the TR tube igniter-electrode discharge will cause some degradation of the maser low-noise characteristics. No attempt was made to measure the noise temperature under these conditions. It is expected, however, that the total effective noise temperature can be increased by at least 30°K.


TR TUBE SPIKE LEAKAGE SPEC LIMIT
TOTAL SPIKE LEAKAGE THROUGH TR TUBE
OPERATING CONDITIONS
PULSE LENGTH = 0.1 μ SEC
PULSE REPETITION RATE = 1000 PPS
SPIKE LEAKAGE - ERGS PER PULSE
1 X 10⁻¹
1 X 10⁻²
1 X 10⁻³
1 X 10⁻⁴
TOTAL MASER GAIN
0 2 4 6 8 10 12 14 16 18 20
DETERIORATION OF MASER GAIN — DB

gure 5 — Effect of spike leakage on maser gain — Type 6334 Dual TR tube.

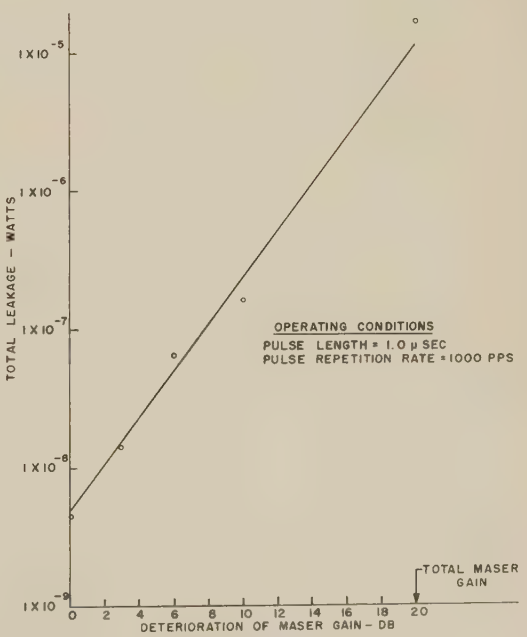

1 X 10⁻⁵
1 X 10⁻⁶
1 X 10⁻⁷
1 X 10⁻⁸
1 X 10⁻⁹
TOTAL LEAKAGE - WATTS
OPERATING CONDITIONS
PULSE LENGTH = 1.0 μ SEC
PULSE REPETITION RATE = 1000 PPS
TOTAL MASER GAIN
0 2 4 6 8 10 12 14 16 18 20
DETERIORATION OF MASER GAIN - DB

Figure 6 — Effect of total leakage (spike and flat) on maser gain — Type 1B63A.

Figure 7 — Effect of total leakage (spike and flat) on maser gain — Type 6334 Dual TR tube.

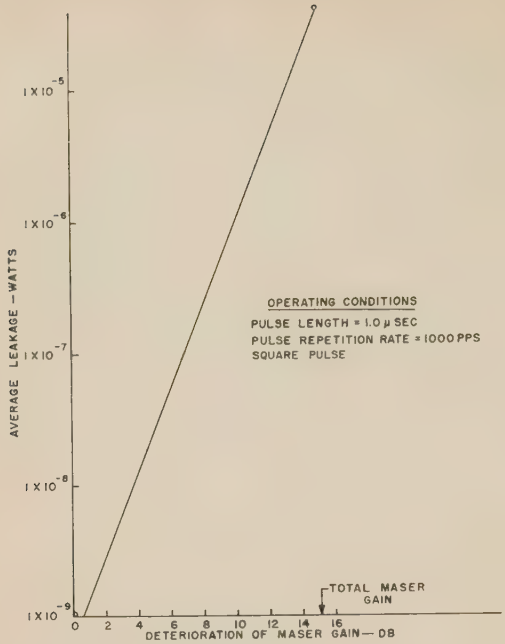

AVERAGE LEAKAGE — WATTS
1 X 10⁻⁵
1 X 10⁻⁶
1 X 10⁻⁷
1 X 10⁻⁸
1 X 10⁻⁹
OPERATING CONDITIONS
PULSE LENGTH = 1.0 μ SEC
PULSE REPETITION RATE = 1000 PPS
SQUARE PULSE
TOTAL MASER GAIN
0 2 4 6 8 10 12 14 16
DETERIORATION OF MASER GAIN — DB

Figure 8 — Effect of flat leakage power on maser gain (no TR tube).

It will be extremely difficult if not impossible to achieve the required degree of protection using conventional duplexer tubes. Pre-pulsing techniques can be utilized to eliminate spike leakage effects and ignitor electrode noise. However, there appears to be no straightforward, acceptable design method to sufficiently reduce the flat leakage power. Increasing the number of TR tube elements will minimize the flat leakage power, but at the expense of increased insertion loss. This condition is generally unacceptable.

Several approaches are being investigated to solve the problem of adequately protecting a maser against input signals that cause saturation. The use of ferrite and solid-state semiconductor types of switches and power limiters shows considerable promise. Gas-discharge pulsed attenuator tubes are also being studied. Each of these devices, however, must be used in conjunction with a high-power duplexing element, such as a gas discharge

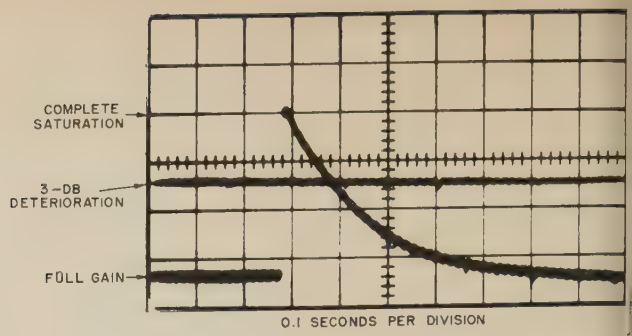


Figure 9 — Results of recovery time test.

pre-TR tube or a ferrite circulator, if a single-antenn system is used.

The use of separate antennas for transmitting and r ceiving has been proposed. This approach also requir the use of some type of power-limiting device in the r ceiver system. In addition to protection against the d sired incoming signal whose level may be high enoug to saturate the maser, protection must also be provide against interfering signals from possible nearby syste and spurious radiation.

Maser materials which can be used in a higher sign level environment are also being investigated.

Acknowledgment

The authors wish to express their appreciation to M Edward E. DeCamp, Jr., for his valuable assistance i making the necessary measurements.

Footnotes

1. Developed for the U. S. Army Signal Research and Deve opment Laboratory by the Hughes Research Laboratorie Culver City, California, under Contract DA 36-039 sc-7495
2. Techniques for measuring pertinent characteristics, such spike leakage, flat leakage, and recovery time, as well detailed analysis of these phenomena, are described Volume 14, Microwave Duplexers, Smullin and Montgon ery, McGraw-Hill Book Co., Inc., 1948. Appropriate me surement techniques will also be discussed in the Propose Standards on Electron Tubes: Methods of Testing TR an ATR Tubes, which will be published in a forthcomin issue of the PROCEEDINGS OF THE IRE.

LIGHTWEIGHT VERY-WIDE-BAND INTEGRAL PACKAGE TWT'S

C. LOUIS CUCCIA
RADIO CORPORATION OF AMERICA
Harrison • New Jersey

The Miniaturized, Wide-Band Traveling-Wave Tube

Since World War II, the traveling-wave tube has been the subject of intensive theoretical and experimental development. As a result, it has achieved a unique status as the only microwave amplifier tube capable of providing substantial power gains over bandwidths of more than an octave at power levels ranging from a few milliwatts to several kilowatts.

As traveling-wave-tube development progressed, it followed four very different paths; (1) very-low-noise types having noise figures less than 7 db,[1 to 17] (2) very-high-power, narrow-band tubes having power outputs from tens of kilowatts to many megawatts,[18, 19, 20] (3) types for such applications as some ground-based radar and radio-relay systems in which size is of secondary importance,[17, 21, 22] and (4) the very-light-weight, miniaturized integrally-packaged traveling-wave tube[23 to 32] capable of operation over very wide bandwidths. Such integrally-packaged tubes put out from 1 milliwatt to 5 kilowatts at frequencies above 1000 megacycles, and are particularly adaptable to jet aircraft and other airborne applications.

This paper is concerned only with the development and structures of traveling-wave tubes falling in the latter category. Although the development of miniaturized, wide-band traveling-wave tubes is very recent, it has become so accelerated that tubes of very advanced design are now available industry wide on a commercial basis. Moreover, such tubes, originally designed for airborne-electronic-counter-measures applications, are also being used in many new and different systems because of their ability to fit small equipments and to perform a wide variety of electrical functions such as amplification, mixing, phase shifting, noise generation, and frequency multiplication and translation.

B. The Focus Structure and Its Modernization

Early traveling-wave tubes used magnetic focusing fields provided by heavy cumbersome solenoids. During the 1950's, new advances in materials and techniques had far-reaching influence upon traveling-wave-tube focus structures. New ferroelectric materials provided magnet components of exceedingly high coercive force and made practical periodic-permanent-magnet focus structures possible. New developments in the use of aluminum foil led to the development of very-lightweight, reduced-size focusing-solenoids, and new techniques for the fabrication and processing of ceramic, metal, and glass made possible not only the development of tube envelopes of improved design, but also the structures required in ruggedized traveling-wave tubes in general.

Modern traveling-wave tubes now use a variety of focus structures, all adaptable to be integrally-packaged with the traveling-wave tube components to provide a complete package of reduced size and weight. These modern focus techniques include (1) uniform-field structures such as aluminum or copper-foil solenoids or uniform-field permanent magnets, (2) electrostatic focus structures, and (3) periodic permanent magnet focus structures.

Figure 1 compares a modern 2½ pound package of a modern medium-low-noise periodic permanent-magnet focused traveling-wave tube with an RCA 6861 low-noise tube and its solenoid which weighs 40 pounds and consumes 150 watts of focusing power. The photograph clearly shows the considerable reduction in size and weight which has made these new microwave amplifiers attractive for use in many new systems.

C. Low-Noise Tubes

The sensitivity of any amplifier system operating at any frequency depends upon the effectiveness with which "shot

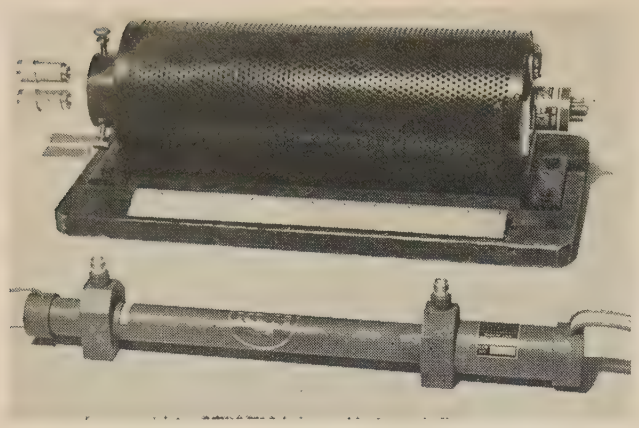


Figure 1 — Photograph (top to bottom) of the RCA-6861 low-noise traveling-wave tube installed in a 40 pound solenoid, and S-band integral-package medium noise traveling-wave tube focused by periodic permanent magnets.

noise" originating in the input stage of the system is minimized. The noise characteristic of a device is expressed in terms of its "noise figure," defined as the ratio of the signal-to-noise ratios at the input and output of the device.

Only traveling-wave tubes employing special low-noise electron guns function as low noise amplifies. However, the noise figure of the first traveling-wave tube operating at high gain as a driver of a chain of amplifier tubes determines the noise figure and, thus, the sensitivity of the entire system; by using a low noise traveling wave tube as the first tube, succeeding tubes are not required to be low-noise devices.

Low-noise performance was one of the first features of the traveling-wave tube to call attention to its potentialities as a microwave amplifier. In the earliest investigation of the traveling-wave tube, Kompfner[1] measured a noise figure of 11.0 db. Research by Dr. D. Watkins[4] at Stanford University and Dr. R. Peter[6] at the RCA Laboratories in the late 1940's resulted in the development of the low noise electron gun. Dr. Peter reported a noise figure of 8.5 db in 1952 and his work was carried into product development, culminating with the commercial announcement in 1956 of the RCA 6861 with a noise figure of 6.5 db. The effort toward lowering the noise figure of the traveling-wave tube has continued with several workers in the field reporting noise figures of less than 3 db and Shaw, Siegman and Watkins predicting the feasibility of attaining noise figures of 1.6 db in S-band.[15]

Table I compares typical performance data for various traveling-wave tubes at S-band frequencies, and some achievements in lowest noise figure for such tubes in this band:

These data show clearly that low-noise tubes designed for octave bandwidth and light weight have noise figures in the 8 to 15 db range — noise figures substantially greater than those characteristic of traveling-wave tubes designed specifically for low-noise operation. In many airborne systems application, however, such an increase in noise figure is entirely tolerable in view of the advantages realized in bandwidth and weight.

The noise figures of the order of 10 db, which are representative of the uniform-field-focused wide-band tubes do not represent the ultimate for these wide-band tubes but rather the state of the art. This art is very young when compared to the effort which has been directed toward low-noise traveling-wave tubes in the last 15 years.

II. BASIC TUBE COMPONENTS

A. The Basic Components

The basic structure of a traveling-wave tube is shown in Figure 2. The tube contains a slow-wave structure such as a helix, along which the wave to be amplified

TABLE I

Device	*Typical Noise Figure db*	*Lowest Noise Figure db*	*Bandwidth % of Octave (2000 to 4000 mc)*	*Focus Means*	*Weight (lb.)*
Light-Weight Wide-Band Tube					
Traveling-Wave Tube (RCA Dev. No. A-1119)[51]	8-10.5	6.4	100	Uniform — Field Miniaturized Solenoid	7
Traveling-Wave Tube (RCA Dev. No. A-1173)[76]	13-15	10.5	100	Periodic Permanent Magnet	2½
Non-Light-Weight Medium Bandwidth TWT					
Traveling-Wave Tube (6861)[17]	6.5	4.1	40	Solenoid	40
Lowest-Noise TWT Achievements					
Chang[70]	—	9.6	—	Periodic Permanent Magnet	—
Caulton and St. John[12]	—	3.5	—	Solenoid	—
Currie and Forster[14] (BWA)	—	2.9	—	Solenoid	—
Watkins - Johnson WJ-211	—	2.7	—	Solenoid	—
Hodowanec - Walkstein (RCA DEV. No. A-1207)	—	2.5	—	Solenoid	—

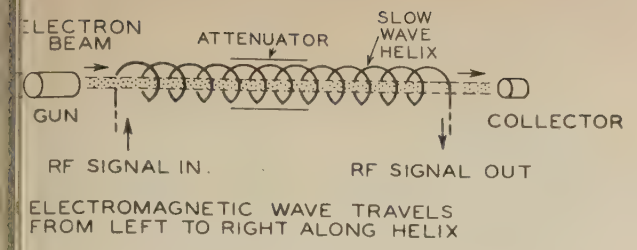


Figure 2 — Basic traveling-wave-tube structure.

avels, and an electron gun which projects an electron am through the helix to the collector.

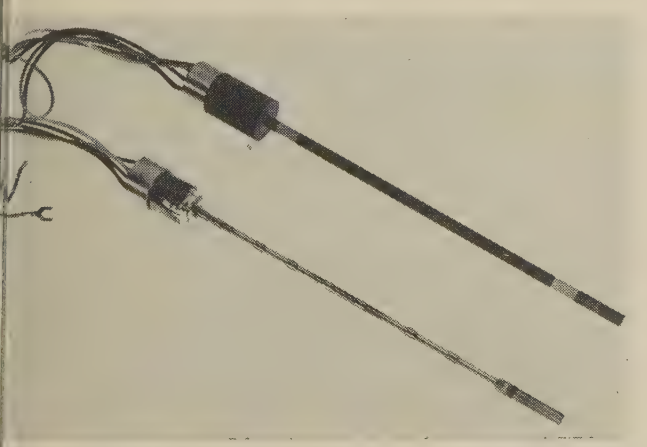
The essential components of the traveling-wave tube e the electron gun, the slow-wave helix structure, the llector, the circuits used to couple r-f energy to and om the helix, and the focus structure which prevents e beam from being intercepted by the helix by focus- g the beam to the collector over a distance of at least veral inches.

As the emphasis in traveling-wave tube development as placed on light weight, integral packaging, and ggedization, as well as on octave-bandwidth operation, e following electron-tube envelopes, helix and gun uctures, and r-f-coupling structures were found to ve the most merit.

Electron-Tube Envelopes

Figure 3 illustrates two of the most widely used types electron tube envelopes; the glass envelope and the tal-ceramic envelope.[33, 34, 35] Both types of envelopes e designed to house the electron gun, the helix, and e collector, and are structures of great strength. The lass envelope is used in most frequency ranges because f its ability to support a precision-wound helix and provide coupling to the helix from external coupling omponents. The metal-ceramic envelope shown is most sed at higher microwave frequencies because the cer- mic windows interspaced with the metal envelope mem- ers, as shown, permit the use of waveguide-to-antenna oupling, and because ceramic-rod support of the helix readily accommodated in this structure.

A derivative of the metal-ceramic electron-tube en- elope is the all-metal envelope[36, 37] (not illustrated)



igure 3 — Photograph showing both glass and metal-ceramic envelopes used for a 1 watt X-band traveling-wave de- signed to be focused by periodic permanent magnets.

which requires special r-f coupling components to the helix.

C. Helix Support

The method used to support the slow-wave helix determines the dielectric loading of the helix, the precision with which the turns-per-inch ratio is maintained, the ability of the helix to withstand mechanical shock and vibration, and the type of input and output coupling that can be used.

Three methods of helix support used in traveling-wave tubes wherein the r-f couplers are mechanically separate from the electron tube envelope are shown in Figure 4.

The use of flutes or ridges on the inside surface of the helix envelope, shown in Figure 4a, yields ideal helix-support structure in glass-envelope electron tubes because the point-type contacts between the flutes and the helix produce minimum dielectric loading, and therefore, cause very little loss ot gain. This type of support also permits the installation of the internal helix close to the wall of the envelope for optimum coupling of the helix to external helical couplers.

The "embedded-helix" structure shown in Figure 4b is used in glass-envelope tubes specially designed to withstand vibration and shock. In this type of construction the fluted glass envelope containing the precision-wound helix is heated until the glass softens, and the glass flutes are then pressed into the helix. The effective helix support provided by this "envelope-shrinkage" technique maintains the precision-wound nature of the helix during axial and lateral vibration.

The ceramic-rod supports shown in Figure 4c are designed for helices which have an antenna at each end and are used in either the glass or the metal-ceramic electron tube envelope. This type of helix support may itself be supported by clamps (not shown) in contact with the inner surface of the envelope or by the inner surface itself. Ceramic-rod supports are ideal for X-band tubes because they provide effective support of the small-diameter helices characteristic of tubes designed for such high frequencies.

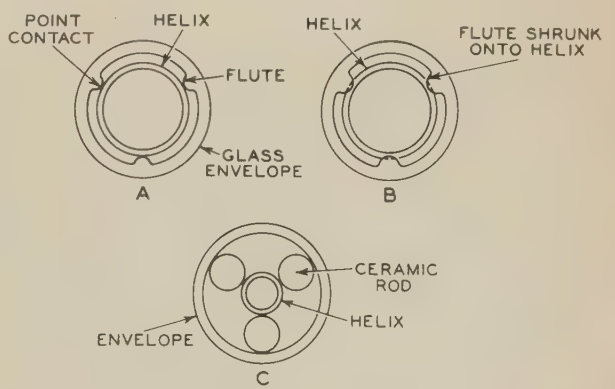


Figure 4 — (a) Helix supported by flutes on the inner surface of a glass envelope;
(b) helix supported by fluted glass tubing with flutes embedded into the helix;
(c) ceramic-rod-supported helix.

D. Attenuator

A traveling-wave tube provides r-f isolation between the input and output circuits of the tube and prevents reflected waves in the helix or backward waves in the electron beam from producing oscillations by use of an internal or external attenuator[38] positioned at a point between the input and output ends of the helix.

Integral-package traveling-wave tubes using fluted-glass envelopes for helix support may use external-helix type attenuators which provide loss by electro-magnetic coupling of a lossy helix through the tube envelope to the slow-wave helix, or by strips of lossy material in contact with the helix inside the tube envelope. Traveling-wave tubes using rod-supported helices are provided with internal attenuators consisting of Aquadag or carbon coatings on portions of the support rods in contact with the helices.

A new type of attenuator, the ferrite attenuator,[39, 40, 41] is presently undergoing investigation, and may prove to be useful in integral-package tubes.

E. Low Noise Electron Guns

The principle source of noise in a traveling-wave tube is "shot noise" originating at the tube cathode. The shot noise is minimized at the entrance to the helix if the beam experiences an exponential rise in potential as it travels through the electron gun. This rise in potential is provided by a low-noise electron gun devised by Dr. R. Peter.[6] (Others prominent in the design of low-noise types of electron guns have included D. A. Watkins[4] and M. Currie[14]).

Figure 5a shows the construction of a typical "Peter" low-noise electron gun. The gun uses a small, flat, space-charge-limited cathode immersed in an axial magnetic field to produce a parallel-flow electron beam. The beam passes through a series of apertures positioned and operated at potentials to produce the required exponential rise in voltage.

F. The Convergent-Flow Gun

The convergent-flow gun was proposed originally by J. R. Pierce,[42] as a means of obtaining a convergent flow of space-charge electrons without the use of a magnetic field. A typical modern convergent-flow gun using a grid design devised by H. Wolkstein is shown in Figure 5b. The space-charge electrons are emitted by a large concave cathode, and converged into a narrow beam before they enter the drift tube by electrodes of

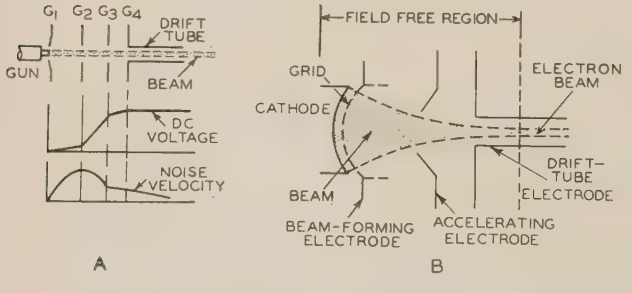


Figure 5—(a) Low-noise "Peter" gun and electron gun and characteristic voltages and noise velocities;
(b) grid-controlled convergent-flow electron gun.

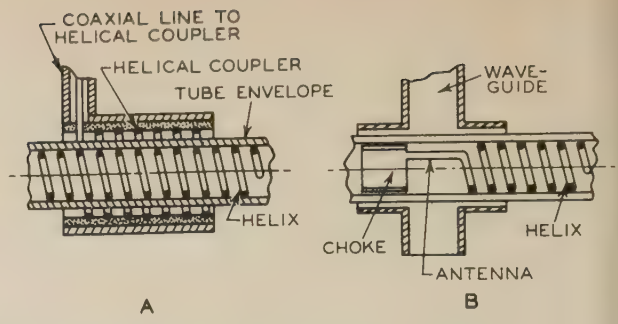


Figure 6 — (a) A helical coupler and main helix structure; (b) a waveguide coupler and helix structure.

appropriate design. Convergence ratios of 4 to 1 and more are used to obtain beams of proper diameter (beam minimum) at the point of exit from the gun, and cathode surfaces of minimum loading.

G. Coupling to the Helix

A traveling-wave tube, like a conventional triode or multigrid tube used as a wide-band video amplifier requires input and output coupling circuits having the proper bandwidth and impedance characteristics. An important difference is that in the traveling-wave tube these input and output circuits are incorporated in the tube package. Consequently, a traveling-wave tube is a complete microwave amplifier stage.

Helical couplers are suitable for use at frequencies up through X-band; waveguide couplers are used for frequencies in C-band and above. Both types of couplers can provide good impedance match to a helix structure over very wide frequency ranges, and have the advantage that they are external to and mechanically separate from the tube envelope. Their small size also makes them particularly suitable for use in integral-package tubes.

A typical external-helix coupler[43] capable of undirectional coupling to the helix is shown in Figure 6a. An external helix is wound in a threaded teflon sleeve and is connected by a short coaxial line to a coaxial connector. This helix is external to the tube envelope, but concentric with the internal helix to which it is electromagnetically coupled through the tube envelope.

Figure 6b shows a waveguide-to-antenna coupler arrangement for coupling to the helix. This arrangement was used almost exclusively with all early experimental tubes. The waveguide coupler couples through the tube envelope to an antenna at one end of the helix. This type of coupler is ideal for use in integral-package traveling-wave tubes operating at X-band and higher frequencies because of the small sizes and low losses of waveguides at these frequencies.

H. The Collector and Depressed Collector Operation

The collector of the traveling-wave tube is a very important component because it functions as the point of collection of the electron beam. In addition, the product of the beam current and the collector voltage represents the principle power dissipation (apart from the filament power) product in the tube. As a result, the collector must withstand high temperatures and

st be capable of being cooled by either liquid or , or by connecting a heat sink (such as the capsule). In some traveling-wave tubes the collector may be pecially designed to permit operation at greatly de-essed voltages,[44, 45] which are substantially below helix tage. This results in a drastic reduction in dc power pplied to the tube. Space charge instabilities are oided, and secondary and primary electrons are pre-nted from returning from the collector to the helix by e of a multisection hollow collector which is mag-tically shielded to cause beam defocusing. F. Sterzer[45] s used such a technique on a 100-watt S-band tube achieve an efficiency (determined by the ratio of the tput power plus the helix dissipation to the collector ssipation) of 53 percent.

. UNIFORM-FIELD-FOCUSED, LIGHT-WEIGHT TRAVELING-WAVE TUBES

Solenoid Focusing of Electron Beams

Uniform-field focusing is used in all traveling-wave bes designed for lowest-noise operation. The ability a solenoid to produce uniform fields in excess of 00 gauss also makes the solenoid useful for focusing e electron beams having the high current densities aracteristic of higher-power tubes.

Modern developments in the use of copper and alu-num foil in solenoids[46, 47, 48] have made possible dras- reductions in solenoid size and weight. These sole-ids are wound in the form of wafers[47] which are con-cted in series to produce a final component requiring voltages from 70 to 200 volts and 1 to 3 amperes.

Such aluminum foil solenoids have had wide appli-tion for traveling-wave tubes,[49, 50, 51] having power tputs ranging from the milliwatt to kilowatt level.

. Miniature Solenoid Low-Noise Tubes

Most traveling-wave tubes using solenoids and de-gned for power amplification from very-low powers the kilowatt and 10 kilowatt level have been replaced r are being replaced by periodically focused traveling-ave tubes which provide comparable performance with ss size and weight, and need no solenoid power supply.

However, the solenoid-focused tube, even for very ide-band operation, yields noise figures several db wer than those of the best periodically focused low-oise tubes (see Table I). While this disparity in noise gures prevails, aluminum-foil solenoid-focused low-oise tubes will continue to find wide application.

Figure 7 shows an integrally-packaged low-noise ube[51] which includes both an electron-tube and r-f-upler assembly, and a solenoid weighing only 6 ounds in the tube capsule.

The solenoid for this tube is wound of aluminum oil, requires 90 volts and 2.3 amperes, and provides n axial magnetic field of approximately 450 gausses. t is housed in a brass cylinder 2½ inches in diameter nd 13½ inches long; the magnetic field is developed in cylindrical center tube 0.850 inch in diameter. The olenoid is cooled by forced air which travels through passage between the outer surface of the aluminum-oil windings and the inner surface of the brass cylinder.

The miniaturized electron tube shown in Figure 7 has a gun bulb less than 0.750 inch in diameter, and uses an internally fluted helix envelope having an inner diameter less than ⅛ inch. This tube uses helical couplers. The electron tube, helical couplers, and attenuator are mounted in a rod-and-plug cage, and the assembly is potted in an aluminum cylinder ¾ inch in diameter.

Models of the above tube were designed for operation in the 1000 to 2000-megacycle and 2000 to 4000-megacycle frequency octaves. Gains in excess of 25 db and noise figures in the 8-10.5 db range were obtained for tubes operating in both frequency octaves. Although these noise figures are slightly higher than the 6.5-db noise figures obtainable with the 6861, the achievement of high gain over full frequency octaves and greatly reduced size and weight more than compensates for increased noise figures for many types of electronic countermeasures radar systems, where the increased noise figure is tolerable.

C. Uniform-Field Magnet Focusing

While the solenoid was being modernized, advances in the design of uniform-field permanent magnets by M. S. Glass[52, 53] have made such magnets of continued usefulness in traveling-wave-tube systems. A uniform-field permanent magnet was successfully employed to focus the low-noise S-band RCA 6861 without any degradation of low-noise performance. However, the magnet weighed substantially more than the solenoid normally employed with these tubes. On the other hand, for X-band frequencies at which small size and very short lengths are characteristic of low-noise electron tubes, uniform-field permanent magnets weighing less than 10 pounds have been used to advantage.[34]

IV. ELECTROSTATICALLY FOCUSED TRAVELING-WAVE TUBES

A. Electrostatic Focusing

Electrostatic focusing of the electron beam in a microwave amplifier was first suggested by Hahn and Metcalf[54] in 1939, as applied to velocity-modulated tubes. In 1948, Dr. R. Peter[57] analyzed the use of the

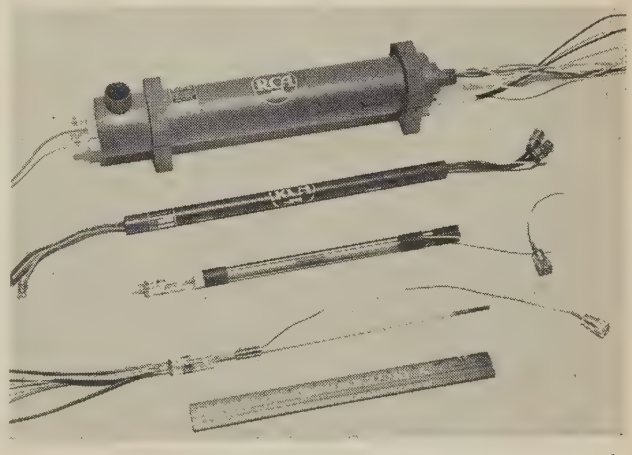


Figure 7 — A solenoid-focused integral-package low-noise tube and its component parts.

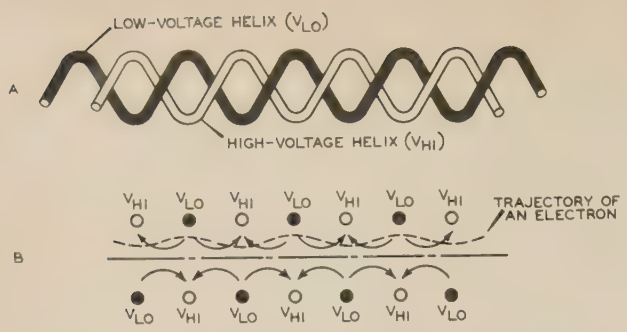


Figure 8 — (a) Cross-sectional view of a bifilar-helix type of electrostatic focus structure;
(b) forces exerted on an electron passing through an electrostatic focus structure, and the resulting electron trajectory.

bifilar helix as a combined slow-wave and electrostatic focusing structure in an unpublished RCA Laboratories report.

In the 1950's, electrostatic focusing of traveling-wave tubes became a major research and developmental effort.[55 to 63] In 1954, Dr. P. K. Tien [55] published a detailed study of the bifilar helix. In 1956, Dr. R. Adler [56] disclosed the development of an electrostatically focused transverse field tube. In 1957, Dr. K. K. N. Chang[57, 58] disclosed the successful operation of a bifilar-helix traveling-wave tube which functioned as an amplifier. This effort was followed up by Blattner and Vaccaro [60] who developed the first wide-band all-electrostatic focus bifilar-helix tube, this tube providing more than 10 watts output in S-band. This tube was subjected to product development by Cuccia and Johnson.[62]

In 1959, Belohoubek, Siekanowicz and Vaccaro [63] disclosed an important advance in the art of electrostatic focusing — an X-band tube which focused more than 5 amperes of beam current to the collector and yielded power outputs as great as 10 kilowatts. This tube demonstrated for the first time the capability of electrostatic focusing to focus electron beams comprising beam currents in the many-ampere range.

B. How Electrostatic Focusing Works

A traveling-wave tube can be electrostatically focused with the bifilar-helix structure shown in Figure 8a. This structure consists of a pair of interleaved helices having the same diameter and turns-per-inch ratio. When the two helices are operated at different potentials, they produce the same effect as a series of lenses spaced at very small intervals.[55, 57, 58] The focusing action is, therefore, repeated at very small intervals and is used to balance the outward radial force on the electrons. The electrons experience net inward focusing force because they pass more slowly through regions where the electrostatic focusing field is directed inward than through regions when this field is directed outward. The forces exerted on an electron and the resulting electron trajectory are shown in Figure 8b.

The bifilar helix not only provides focusing action, but has the same wide-band characteristics and the same ability to couple to helical couplers as a single-helix slow-wave structure, and therefore, its use in a traveling-wave tube results in no degradation of performance.

C. A 5-Watt S-Band Electrostatically Focused Estiatron

Traveling-wave tubes employing all-electrostatic beam generation and focus are called Estiatrons, after the Greek word ESTIA meaning to focus. Figure 9 shows a packaged Estiatron [62] and its components: the self-focusing electron tube, the attenuator, and the input and output helical couplers. This tube uses a convergent-flow gun which projects an electron beam down a self-focusing bifilar helix, and provides a saturated power output of the order of 5 watts in the 1800- to 3800-megacycle frequency range.

Successful fabrication of the Estiatron required the development and refinement of a new technique for positioning and bonding the bifilar helix in the glass envelope so that the turns are held in precision alignment. In this technique, the component tungsten helices are wound on a mandrel with separators between the adjacent turns of the two windings. A "glass-shrinking" process is then employed to bond the two helices to flutes in the tube envelope. The separators are then removed, leaving the bifilar helices firmly bonded to and supported by the flutes.

The total helix interception of the Estiatron is less than 3 milliamperes when the low-voltage helix is operated at a fixed voltage of 700 volts, the high voltage helix is operated 2800 volts, and the beam current is 30 milliamperes. The helix interception to both the high and low-voltage helices does not change appreciably with changes in high-voltage-helix voltage over the range from 1800 to 3000 volts, showing that electrostatic focus is not critical.

V. INTEGRAL-PACKAGE TUBES USING PERIODIC PERMANENT-MAGNET FOCUSING

A. Periodic-Permanent-Magnet-Focused Tubes

Integral-package traveling-wave tubes using periodic permanent-magnet focus have been developed to service many different output-power levels in different frequency ranges from less than 1000 megacycles to more than 12,000 megacycles.

Periodic magnetic field focusing was first suggested in 1952 by Courant, Livingston, and Snyder [64] at Brookhaven National Laboratory in connection with the focusing of a synchrotron.

At this time two concurrent but independent investigations of the use of periodic permanent-magnet focusing for traveling-wave tubes started. One was at the

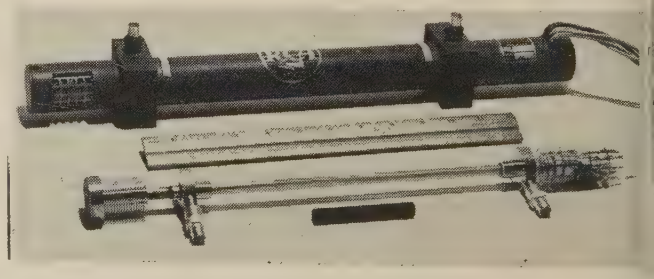


Figure 9 — The final package and component parts of the electrostatically-focused Estiatron. The electron tube and input and output couplers, shown separately, are all that are required for tube focus and RF operation.

l Telephone Laboratories, where Dr. J. R. Pierce[65] d his associates Clogston and Heffner,[66] and Mendel, ate, and Yocom[67] disclosed in 1953-1954 the operan of an X-band traveling-wave tube amplifying at 000 megacycles which, with focus structure, weighed s than 2 pounds.

At the RCA Laboratories, Dr. K. K. N. Chang's estigation of periodic permanent-magnet focus-[68, 69, 70] included both a study of the optimum den of focus structures,[69] and the development of a v-noise periodically focused traveling-wave tube.[70] e investigation by Dr. Chang was the start of a conuous effort which included the scientists of the RCA ectron Tube Division, and in 1956, Siekanowicz and erzer[71, 72] disclosed a new type of traveling-wave tube hich has had far-reaching influence on the art. This be used a periodic permanent-magnet focus structure sed on classical theoretical and design principles ught by K. K. N. Chang and was the first wide-band tegral-package traveling-wave tube of advanced elecal and mechanical design. This tube provided 100 tts of r-f output at a gain of 20 db across the 2000 4000-megacycle band, required no focusing power, d weighed less than 15 pounds.

By 1958, four traveling-wave-tube developments, usg periodic permanent-magnet focusing, showed clearly e potentialities of this new focus technique. S-band es developed in light-weight integral packages proded saturated power outputs at the 10-milliwatt and watt level[24, 25] (Wolkstein), at the 10-watt level[23] liss and Pratt), at the 100-watt level[26] (Wolkstein d Novak), and at the kilowatt level[28] (Purl, Anderon, and Brewer).

At the same time, E. E. Bliss[73, 74] demonstrated that riodic permanent-magnet structures could be temperare compensated over very wide temperature ranges.

The development of periodic permanent-magnet-foused traveling-wave tubes, accelerated by the growth of e art of electronic countermeasures radar, has been sponsible for the availability today of many tubes perative at a wide variety of power levels and frequency ranges. In addition, the advanced mechanical esign of these tubes make them capable of meeting ry severe military environmental specifications.

Focusing With Periodic Permanent-Magnet Structures

Figure 10 shows a portion of an arrangement of ring agnets and steel shims designed to produce an axial riodic magnetic field. Each ring magnet is magnetized that north and south poles are produced on its side aces. The ring magnets are then stacked between steel hims with the similarly polarized faces of each pair ijacent.

The facing south poles of adjacent ring magnets proce a south pole in the steel shim between them, and e facing north poles of adjacent ring magnets produce north pole in their common steel shim. The strength f the magnetic field along the axis of the structure thus aries periodically, being zero in a plane through the enter of each steel shim, and maximum in a plane rough the center of each ring magnet.

An electron beam passing along the beam axis and

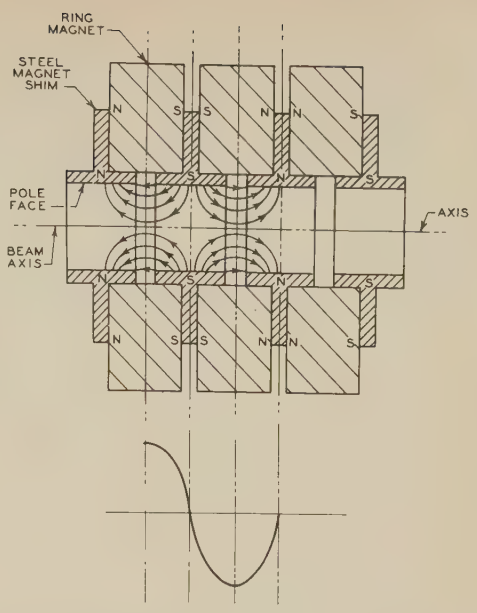


Figure 10 — Cross-sectional view of a periodic permanent-magnet focus structure.

provided with sufficient accelerating voltage is constrained most in regions where the force exerted by the magnetic field is at a peak positive or negative value, and constained least in regions where the magnetic field passes through zero. The electron passing through the periodic magnetic field is alternately deflected toward and away from the central axis, and the electron beam, therefore, has a scalloped outline. The range of electron-beam voltages for which electrons introduced into a periodic magnetic field follow a scalloped path all the way to the collector without interception is referred to as a "transmission pass band."

C. External Magnetic Fields Produced by Periodic Permanent-Magnet Focus Structure

Most uniform-field focus structures produce external magnetic fields which extend considerable distances from the structures. Also, both uniform-field magnet focused tubes and electrostatically focused tubes are adversely influenced by adjacent magnetic materials. The periodic permanent magnet focus structure, however, has external magnetic fields closely confined to the focus structure, so that it is possible to operate tubes using such structures side-by-side or in close proximity to magnetic material without degradation of performance.

D. Convergent-Flow Electron Guns and Periodic Permanent-Magnet Focus Structure

Most periodically-focused traveling-wave tubes not designed for low-noise operation use convergent-flow guns to take advantage of the large cathodes and light space-charge densities at the cathode which contribute to very long tube life.

The field-free region for the convergent-flow gun is obtained by the use of a steel magnetic shield at one end of the permanent-magnet focus structure, as shown in Fig. 11a. The resulting magnetic-field distribution along the axis of the tube is shown in Fig. 11b. The convergent electron beam encounters the periodic-focusing magnetic

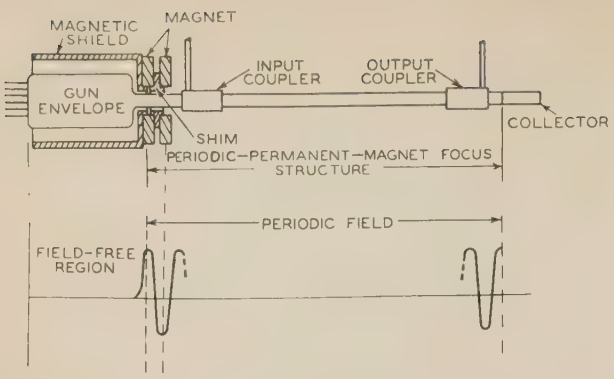


Figure 11 — (a) Periodic permanent-magnet focus structure including a steel magnetic shield at one end which magnetically shields a convergent-flow gun installed in the shield;
(b) magnetic field configuration for structure shown in (a).

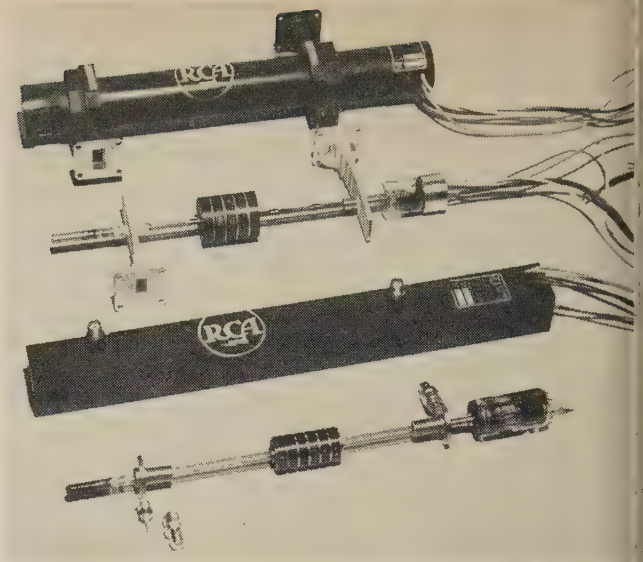


Figure 12 — Photograph (top to bottom) of the final integral package, waveguide couplers, electron tube, and a portion of the component periodic permanent magnet structures of a 1 watt X-band traveling-wave tube; and the completed integral package, the periodic-permanent-magnet focus structure, the electron tube, and the helical coupler of a 1 watt L-band tube.

focusing magnetic field at a point in the drift tube where the converged beam has minimum diameter.

Figure 12 is a photograph showing, at the top, the final integral package, the waveguide couplers, the electron tube, and a portion of the periodic focusing structure of a 1-watt X-band tube; and at the bottom, the final integral package, helical couplers, electron tube, and a portion of the periodic focusing structure of a 1-watt L-band tube.

The integral packages typified by the structures of Fig. 12 are uniquely adapted for mass production. The ring-magnet and shim structure is separately fabricated and magnetized, and then installed with precision-made helical couplers. The electron tube is mechanically separate from the focus and coupler structure, and is constructed by means of traveling-wave-tube and electron tube techniques. During assembly of the integral package, the electron tube is inserted into the couplers and focus package, and supported by the radiator at the collector end and by a screw arrangement at the gun end. Thus, the integral package is made up of separately fabricated and processed parts which then require only an assembly and positioning operation.

E. Low-Noise Periodic Permanent-Magnet Focused Tubes

The uniform-field region required for use with a low-noise gun is provided, as shown in Fig. 13a, by a uniform-field structure installed at the gun end of the periodic-permanent-magnet structure. This arrangement was pioneered by Dr. K. K. N. Chang. A specially designed ring magnet and shim between the uniform-field magnet and periodic structure provide a transducer magnetic field which matches the gun field to the periodic field. The resulting field configurations are shown in Fig. 13b. Structures of this type have undergone extensive development, [75,76] culminating in the disclosure in 1959 by Hodowanec, Poelstra, and Nelson[76], of medium-noise figure tubes operable in L-band, S-band and C-band.

Figure 14 is a photograph of the final tube package, the focus structure, the electron tube and the helical coupler of the medium-low noise periodically-focused RCA-4017, which provides amplification across the entire S-band frequency range with noise figures of the order of 13 to 15 db. This photograph shows the magnet section which is used to develop a uniform magnetic field in the electron gun, and the reduced size of the gun bulb and gun structure of the electron tube.

F. Tubes For Different Output Power Levels

Table II is a tabulation of the pertinent electrical and mechanical characteristics of several S-band traveling-wave tubes using standard *single-wound* helices. This table illustrates the various beam currents and helix voltages

TABLE II

RCA Tube Type	*Saturated Power Output Watts*	*Gain db*	*Beam Current ma*	*Helix Volts*	*Length Inches*	*Diameter Inches*	*Weight Pounds*	*Duty Cycle*	*Electron Gun*
4017 +	0.015	35	1	475	15-7/8	1-1/16	2-½	1	Low Noise
4009	0.01	35	3	600	15-3/16	1-1/16	2-¾	1	Gridded Convergent Flow
A-1113*	0.1	35	4	600	14-3/16	1-1/16	2-¼	1	"
4010	1	33	19	1100	15-3/16	1-1/16	2-¾	1	"
A-1166*	10	25	60	2100	18-½	1-½	4	1	"
4007	100	30	250	3700	19-⅝	2-½	12-½	0.1	"
A-1134*	1000	30	1500	7800	21	2-½	15	0.02	"

* Developmental Types
\+ Medium-Low-Noise Tube

ich are representative of tubes of different saturated wer output levels operating over the *entire frequency* ge of 2000 to 4000 megacycles; similar families of es are used in other frequency ranges.

The helices of each of the tubes of Table II increase in meter with increased power output and beam current, lowest power tube focusing its beam current inside a ix having an inner diameter of less than 0.1 inch, and highest power tube focusing its beam current inside elix having an inner diameter of about a quarter inch.

Figure 15 is a photograph showing, top-to-bottom, the kilowatt tube, the 1-watt tube, and the medium-low ise tube of Table II, illustrating the physical sizes of ese tubes designed for widely different saturated power tput levels. The trio of tubes, designed to operate in ndem, has a total gain of the order of 100 db and a urated output power in excess of 1 kilowatt across the 00 to 4000 megacycle frequency range.

Figure 16 is a photograph of the component electron es, magnet rings, shims, and helical couplers of the ree integrally-packaged tubes shown in Fig. 15, show- g the general increase in size of components with in- ased power output.

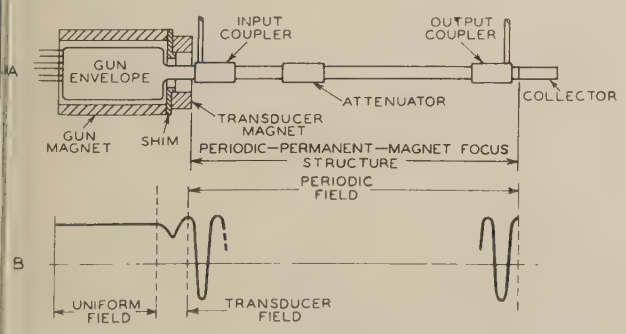
Duty Cycle

Table II indicates that the traveling-wave tubes de- gned for 100 watts and kilowatt for octave-coverage in band have duty cycles less than one; these duty cycles e for the most part limited by helix dissipation. In gen- l, maximum cw powers of the order of 100 watts have en obtained in L- and S-band, because at these frequen- s the helix is of substantial size and has a large area of ntact with the helix support. At X-band, where the lix is very small in length and diameter, cw powers of high as 10 watts have been obtained for high pulse wer outputs.

For traveling-wave tubes using other than the single- ound helix type of slow-wave structure, much higher cw tput powers are possible. Hant, Kresmanis, and Scott[32], r example, have achieved a cw power output of 350 atts at X-band with a periodic permanent-magnet fo- sed tube using an iterated cavity type of slow-wave struc- re having reduced bandwidth.

Ruggedization of Periodic Permanent-Magnet Focused Tubes

The growth in interest in integral-package traveling- ave tubes using periodic permanent-magnet focus struc-



igure 13 — (a) Periodic permanent-magnet focus structure using a permanent magnet at one end to provide a uniform field for the low-noise type of electron gun; (b) magnetic field configuration for structure of (a).

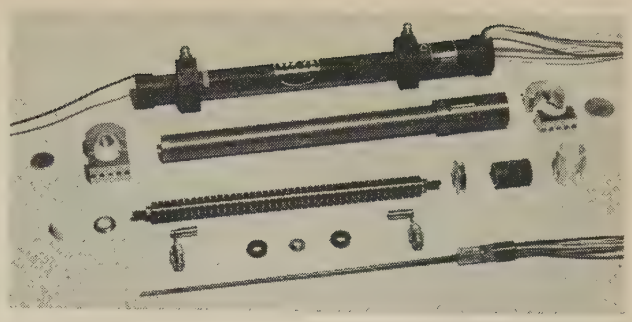


Figure 14 — Photograph of the completed integral package, the periodic permanent-magnet focus structure, and the electron tube the gun magnet and the helical couplers of a periodic focus S-band medium low-noise tube.

tures is due not only to the light-weight and compactness of these tubes, but also to the fact that such traveling-wave tubes can be ruggedized.

Ruggedization of integral package periodic-focus traveling-wave tubes requires at least three design features; i.e., (1) ruggedized support of the helix in the envelope, (2) ruggedized support of the long helix-envelope in the integral package, and (3) maintenance of magnetic-field uniformity over very wide ranges of ambient temperature.

In glass-envelope tubes, features (1) and (2) are accomplished by shrinking the glass flutes onto the helix, and then supporting the envelope at an intermediate point in the tube structure. In one tube, amplitude modulation of 2 db was encountered for axial vibration at approximately 2 g, when the helix was not embedded in the glass. With glass embedding, this amplitude modulation was reduced to 0.25 db, and the additional feature of intermediate support of the helix envelope reduced this figure to 0.1 db. In transverse vibration of the tube, amplitude modulation due to deflection of the center of the helix envelope was reduced from 3 db, when no intermediate support was used, to 0.2 db when intermediate support was included in the structure. In ceramic-rod supported helices, tight support of the rods themselves by clamps or by the envelope, is also an effective method of helix support in both glass and metal ceramic envelopes.

Tubes designed with each of the above helix support techniques have easily withstood 5 g in each of three

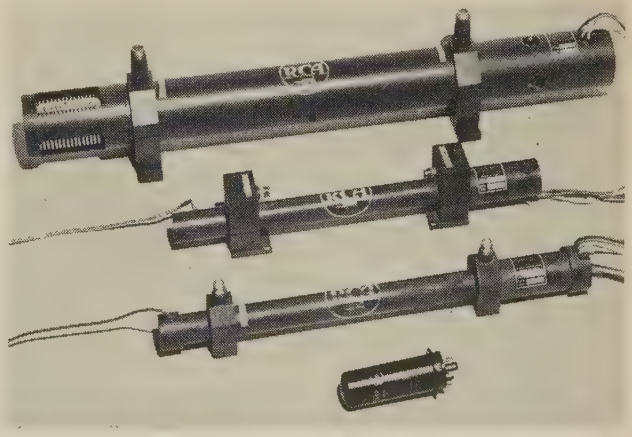


Figure 15—Photograph (top to bottom) of periodic permanent-magnet focused traveling-wave tubes designed for saturated power outputs of 1 kilowatt, and 1 watt, and medium low noise operation, respectively, across the entire S-band frequency octave. See Table II.

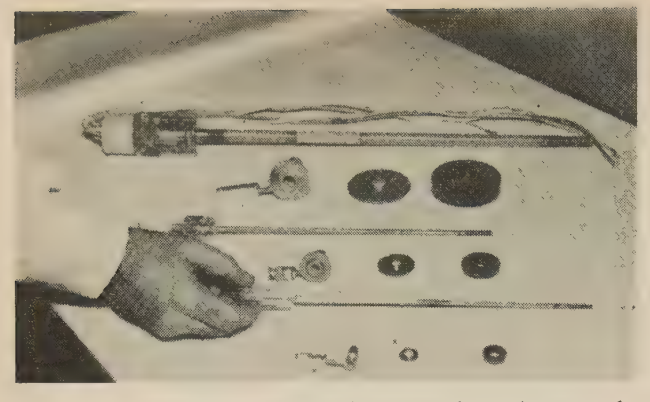


Figure 16 — Photograph (top to bottom) of an electron tube, magnet ring, shim and helical coupler used in each of the 1 kilowatt, 1 watt, and medium low noise tubes of Figure 15.

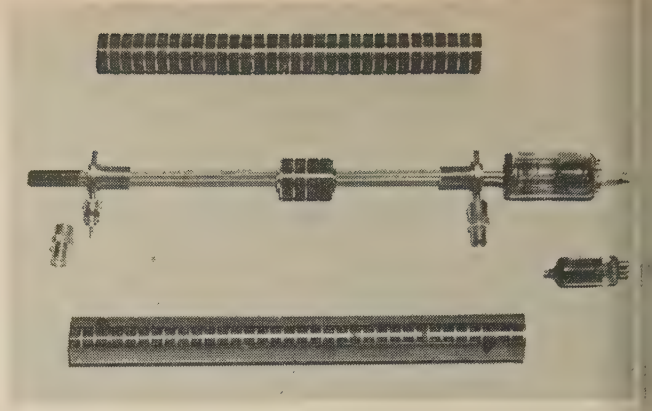


Figure 17 — Photograph of a periodic permanent-magnet focu structure, couplers and tube, and (below) the temperature compensated version of the focus structure, using a sheat of alloy steel as a shunt of temperature-varying permea bility.

directions without degradation of tube performance. Tubes especially designed to meet the highest vibration environment, have withstood vibration in excess of 10 g for vibration up to 2000 cps.

I. Temperature Compensation

The ferrite rings used for the magnet structures have magnetic properties which change by as much as 0.2 per cent per degree centigrade. At this rate of change, most uncompensated magnet structures will experience as much as 50 per cent change in peak magnetic field over the temperature ranges required by military equipment. This peak-magnetic-field vibration has the effect of producing "over focusing" at the low temperatures at which the magnetic field strength is maximum, or poor focusing and excessive helix interception at the highest temperatures at which the magnetic field is lowest.

A novel approach to the temperature compensation of periodic permanent-magnet structures was used by E. Bliss [73] in the development of a 10-watt S-band tube Bliss's approach was to wrap the magnet stack with a spe cial alloy steel, as shown in the photograph of Fig. 17 the alloy steel used has a permeability which increase with decreasing temperature. When the alloy steel i used as a magnetic shunt with ferrites whose remanenc increases with decreasing temperature, the peak magneti field produced by the magnet structure can be maintaine substantially constant over a wide temperature range.

A double-shunt system was used to compensate for tem perature variations at both low and intermediate tempera tures and very high temperatures. This double-shunt system compensated the magnet stack for wide temperatur changes, so that the peak magnetic field varied only 26 gaus ses in 480 gausses between the temperatures of —65 an +135 degrees centigrade. The non-temperature compensat ed tube experienced a change in peak magnetic field of 16 gausses over the same temperature range.

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A WIDE-BAND MICROWAVE LINK FOR TELEMETERING

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Introduction

The general term "telemetering" or "telemetry" pertains to the art of making measurements at a distant or inaccessible location and reproducing these measurements at a convenient location. Depending upon the type of telemetering "system" used, these measurement data can be immediately displayed in various ways or stored for future reduction in a useable form.

The connection between the two locations is commonly referred to as a "link," and may be in the form of a wired or electrical circuit, a modulated radio frequency carrier, a modulated light beam, a hydraulic line, etc. Presently, wired telemetering systems are used in many fields such as public utilities, chemical processing, and pipeline operations.

During the past two decades, and even as early as 1930 when the first successful flights of radio weather balloons were made in Germany, there has been an increasing need for radio telemetering of measurements and information.

Depending upon the amount of data, the accuracy of data, and the information frequency, many types of radio telemetering [1] systems have been devised. Some of the more exotic types employ either or both frequency and pulse modulation techniques. These techniques, in general, make it possible to transmit in a given frequency bandwidth a vast quantity of slowly varying information by multiplexing methods or conversely transmitting information of a very high frequency content.

The radio frequency for transmission of telemetry signals was in the vicinity of 70 megacycles per second during and immediately following World War II. In 1951 a "Telemetering Standards for Guided Missiles" [2] was issued by the Working Group on Telemetering. The allocated frequencies were in the 220 mcs band. As recently as January 1959 the Inter-Range Instrumentation Group, composed of representatives from the various missile ranges and test centers, issued a recommended "Telemetry Frequency Utilization" with parameters and criteria for the 216-260 mcs band, the 1435-1535 mcs band, and the 2200-2300 mcs band.

Telemetry frequency usage, so far, has been dictated by the above mentioned frequency allocations. Many problems have arisen, and some solved, in using these frequencies for special telemetering information requiring specific bandwidths over a given transmission path.

A frequency allocation in the 4 kilomegacycle band was obtained for use with the telemetering r-f link herei described. This frequency was chosen primarily becaus of the wide-bandwidth requirement for transmission of fa risetime and pulse-interval information; and, more im portant, the essential microwave components were avai able.

The 40 mcs bandwidth link, at 4 kmcs, gives a pulse interval accuracy of better than 5 millimicroseconds withi a time interval range of from 0 to 200 microseconds. Thi bandwidth is usually adequate for the accurate reproduc tion of pulse-risetime, pulse-duration, and pulse-amplitud Occasions arise, however, when a bandwidth of 250 mc is required for very accurate pulse shape reproductio These wide bandwidths are necessary because the 4 kmc r-f carrier is pulsed — frequency modulated in order t transmit pulse type information.

General Design

In this telemetering system [3] the r-f link must produce over the required distance of transmission, a video signal-to-noise (S/N) power ratio of at least 20 decibels (db) at the output of the receiver discriminator for reliabl pulse information recovery. Important factors associate with this requirement are receiver noise figure, r-f signa power, and receiver bandwidth.

In the usual field test application of this link the dis tance between the transmitter and the receiver is known The bandwidth needed is determined from the highes frequency component in the pulse information to b transmitted. Therefore the transmitter power required i determined from the following equation: [4]

$$10 \log P_t/P_n = A_p + S/N + (NF) - G_t - G_r - (NIF)$$

where:

S/N = required signal-to-noise ratio input to receive in db.

(NF) = noise figure of receiver in db.

(NIF) = noise improvement factor in db due to modu lation methods where extra bandwidth is use to gain noise reduction.

P_n = theoretical noise power at the input of the receive in watts.

= 0.004×10^{-12}B, or KTB, where K is Boltzmann' constant, T is absolute temperature in degree Kelvin, and B is the bandwidth in megacycle per second.

P_t = transmitter power output to antenna in watts.

G_t = gain of transmitting antenna in db.

G_r = gain of receiving antenna in db.

* Now at Temco Electronics, Dallas, Texas.

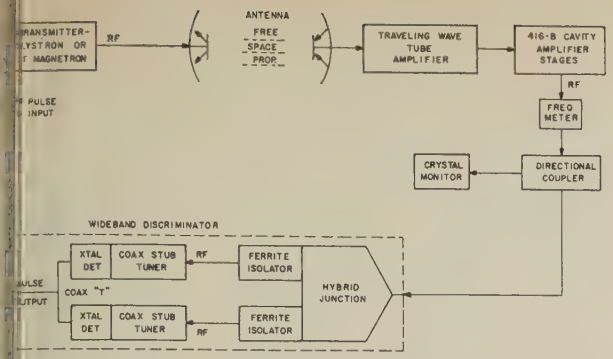

Figure 1 — Pulsed FM microwave telemeter.

A_p = free space path attenuation, dependent upon the distance between transmitter and receiver and the frequency of the r-f carrier.

A value for P_t, chosen from the transmitters presently ilable for use at 4 kmcs, is in the order of 0.5, 1 to 2, 1 5 watts. Calculations made from the above equation ermine the required gains, G_t and G_r, for the trans- ting and receiving antennas. Either horn or parabolic ennas are selected for the required gains to give the essary S/N ratio to the receiver input.

ne block diagram, Figure 1, shows the principal com- ents in the microwave r-f link.[5, 6, 7]

ransmitter: The transmitter used is either a klystron illator or a miniature voltage-tunable magnetron (Fig- 2 and 3). R-f output power is in the order of watt and 1 to 5 watts, respectively, at 4 kmcs for these transmitters. The Western Electric 431A klystron es have an average electronic tuning range of 40 mcs. e General Electric Z-5040 magnetrons,[8, 9] depending on the operating frequency, the particular cavity, and er considerations, can be made to operate over a fre- ency range of 250 mcs in the 4 kmcs region with essen- lly constant power output. High voltage transistor wer supplies (28 vdc input) have been designed for transmitters for future airborne tests.

Antenna: Suitable antennas have been designed for the cessary beamwidth and bandwidth consistent with the tance and the information requirements involved. In st tests a 10 foot diameter parabolic dish precedes the ceiver. This dish antenna gives a beamwidth of approxi-

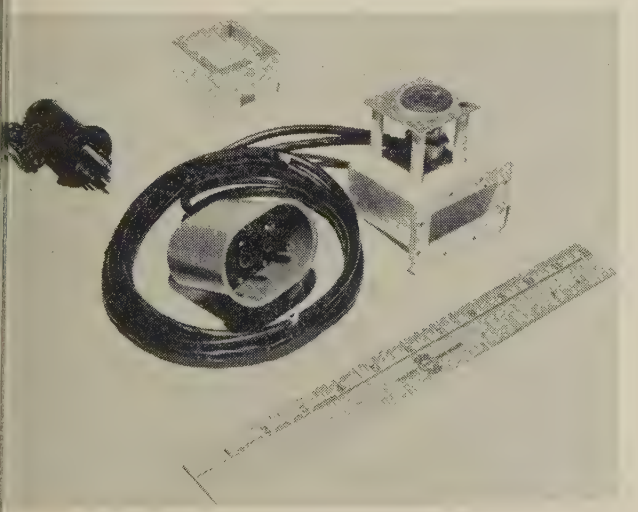

Figure 2 — 431A klystron.

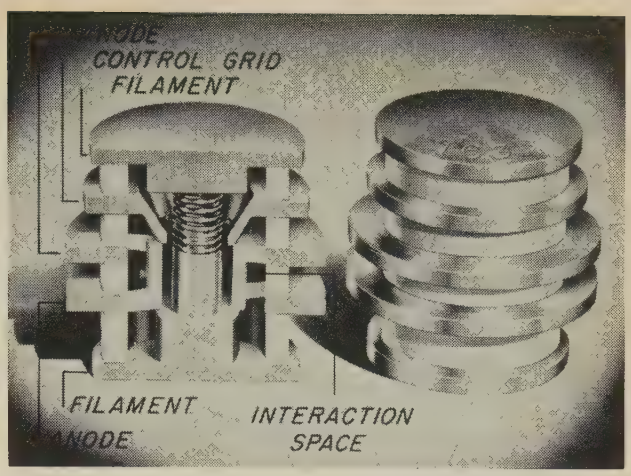

Figure 3 — Z-5040 voltage-tunable magnetron.

mately 1.6 degrees. Several other types of antennas have been used ranging from a single dipole to different length horns and parabolic dishes of diameters varying from 2 to 6 feet.

Receiver: The input stage of the all-r-f microwave receiver utilizes a low-level, low-noise, high gain amplifier to achieve optimum S/N ratio at the receiver output. Succeeding r-f amplifier stages of the receiver will not materially affect the overall receiver noise figure in accordance with the equation: [10]

$$F_{12} = F_1 + \frac{F_2 - 1}{G_1}$$

where

F_{12} = noise figure (power ratio) of two amplifiers in cascade

F_1 = noise figure (power ratio) of the first stage

F_2 = noise figure (power ratio) of the second stage

G_1 = gain (power ratio) of the first stage

A traveling-wave-tube (TWT) amplifier was obtained in the early development stage of the wideband microwave link. The Bell Telephone Laboratories had under development the Type 1819 TWT amplifier (Figure 4 and 5) which used a permanent magnet for electron beam focusing. This amplifier used WR-229 waveguide for the r-f input and output connections. A 16 to 23 db gain, depending upon beam current, with a noise figure of from 6 to 8 db was achieved with this TWT amplifier.

After much usage and quite successful results, these TWT amplifiers were replaced with RCA Type A-1088 TWT's. The RCA tube is made more rugged by en-

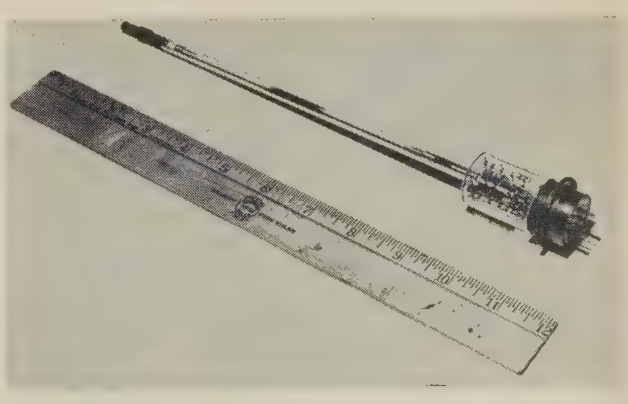

Figure 4 — Traveling-wave tube — Type 1819.

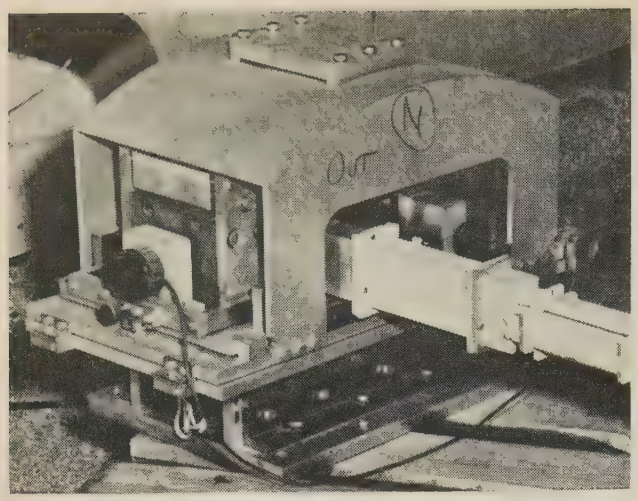

Figure 5 — TWT amplifier circuit.

capsulating techniques; and, in addition, the r-f input and output terminals are coaxial connectors. Magnetic focusing of the beam is accomplished by means of a solenoid and an associated power supply. The resulting amplifier adapts to field operations much better than the original TWT amplifier.

Following the TWT input stage, the system uses tuned grid and plate cavity 416B cascade amplifier stages.[11,12] Individual low-level stage gain and bandwidth average 10 db and 150 mcs, respectively, at 4 kmcs. Although these tubes have low noise figures (2 to 4 db) in the commonly used 220 mcs band, the noise figure becomes increasingly worse at higher frequencies and increases to 16-20 db at 4 kmcs.

A cascaded six-stage 416B cavity setup for the 40 mcs band-width link is shown in Figure 6. To add to the reliability of the r-f link a limiting action is achieved in the receiver to take care of signal vibration due to fading and ducting. When the input r-f signal level to the cascaded amplifier exceeds a value such that the last stage is delivering its maximum output (usually 400 to 500 milliwatts) a condition of compression[12] arises. In compression, the output remains essentially constant with further increase in input signal; therefore the last stage of the amplifier behaves as a limiter ahead of the discriminator. Thus the detected output video signal is essentially constant with an input signal variation of as much as 16 db. The receiver gain is normally adjusted into the compression condition for the expected input r-f signal level.

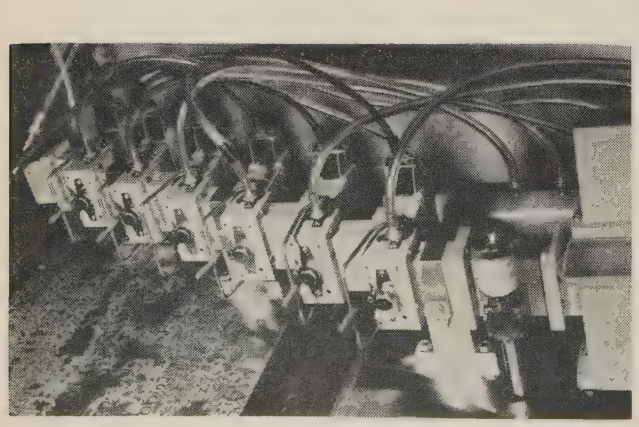

Figure 6 — 416-B amplifiers.

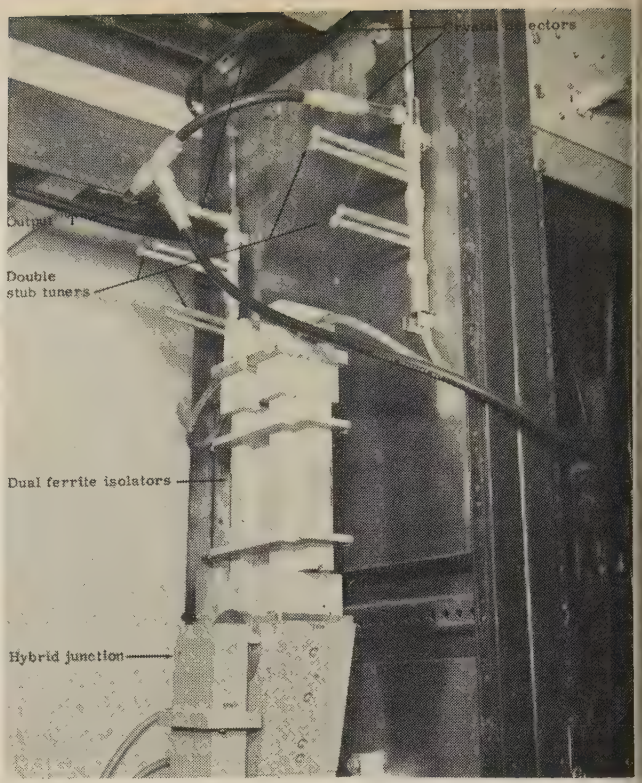

Figure 7 — Discriminator components.

An alternative multistage amplifier, using the proper number of TWT amplifier stages, is now in general use in place of the cascaded 416B amplifiers. The tubes employed in the multistage amplifier are the Alfred Electronics Models 511 and 502. The second, medium-level stage of this amplifier has nominal gain of 30 db with a 10 milliwatt output. A third, high-level, stage with a nominal gain of 30 db has a 1 watt output. With judicious gain adjustment and with the insertion of the proper amount of attenuation between amplifiers, an essentially constant output with varying input r-f signal level can be obtained with these tubes. An additional bandpass filter, with low insertion loss, is sometimes inserted after the last stage to reduce the noise output by decreasing the extremely wide bandwidth characteristic of this TWT amplifier.

Discriminator (Figure 7): The use of a wideband microwave r-f discriminator in this r-f link is considered to be unique. The purpose of the discriminator is to de-modulate the pulse information from the incoming r-f signal. Components for this discriminator are shown within the dashed-line area of the block diagram, Figure 1. As shown in Figure 7, a waveguide hybrid junction[13] ("magic T") divides the r-f signal equally between the two branch arms. When the stub tuners in each of the arms are tuned to obtain a discriminator curve, the ferrite isolators provide isolation between the two arms so that the tuning of one side does not affect the tuning of the other side. Isolation is also provided between the last r-f stage and the discriminator. One of the two crystal detectors is reverse mounted so that the two currents are additive in the output coaxial "T". By setting the stub tuners, the discriminator curve can be made to have the desired linearity with either a positive or a negative slope.

The three curves shown in Figure 8 illustrate the functioning of the wideband discriminator. The crystal cur-

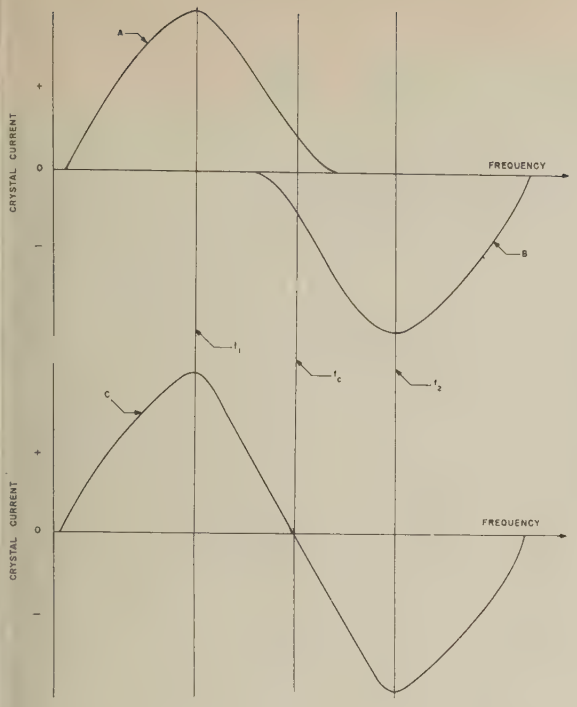

Figure 8 — Discriminator curves.

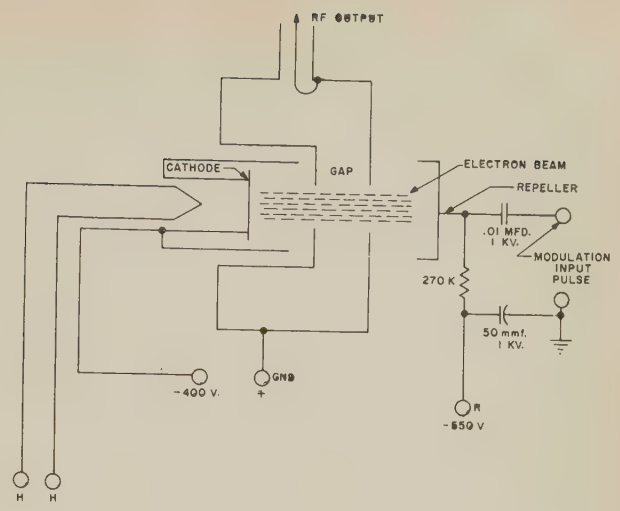

Figure 9 — Klystron schematic.

...t is plotted along the ordinate; and the frequency is ...ted along the abscissa. The double-stub coaxial tuners ...each arm are adjusted so that standing waves are set ... between the crystal mounts and the outputs of the ...ite load isolators. Curve A illustrates one branch arm ...t is tuned to resonance at a frequency f_1 below the ...ter frequency f_c. Curve B illustrates the other branch ...n which is tuned to resonance at a frequency f_2 above ... center frequency f_c. This latter crystal current resonant ...ve B becomes negative because the crystal in this arm ...reverse mounted. The combination of curves A and ...result in curve C. Curve C indicates the discriminator ...tput developed at the coaxial "T" connection when it ...terminated in its characteristic impedance. As the fre...ency of the r-f signal changes with modulation, the ...nding waves of r-f energy in the discriminator arms ...ve with respect to the crystal detector position. The ...stal detects either more or less power, depending upon ... direction of the shifting standing wave pattern. The ...stal, therefore, performs its basic function as a power ...plitude detector. The combined outputs of the two ...stals produces a wideband discriminator characteristic ...ve for the detection of pulsed-frequency modulated sig...s from a microwave frequency carrier.

...ansmitter Modulation

The previously mentioned 431A klystron and the ...5040 magnetron are the two transmitting tubes used for ... 40 mcs bandwidth link. Occasionally, the Z-5040 mag...ron is used for bandwidth applications up to 250 ...s. The most important characteristic of the 431A ...stron is its ability of output frequency to closely fol...w the rapid voltage change applied to its reflector. This ...aracteristic, called "deviation rate," is closely related to ... electronic tuning bandwidth and to the cavity circuit ... of a klystron. The electrical characteristics of the ...1A klystron and the Z-5040 magnetron satisfy the "de-viation rate" requirement. Tests show that a pulse of from 0.015 to 0.020 microsecond risetime is obtainable through the entire 40 mcs bandwidth link, including all transmitter, receiver, and display components, when a 1 millimicrosecond risetime pulse modulates the klystron reflector. The reflector element has a high input impedance and a very low input capacity. The modulation sensitivity for the 431A averages 0.6 mcs/volt when oscillating in the 1¾ mode. A 30 to 40 volt peak input pulse for the 40 mcs bandwidth link is therefore required. The klystron is thereby frequency pulsed over an 18 to 24 mcs swing across the peak of its power output mode. The circuit for modulating the klystron is shown in Figure 9.

In telemetering operations requiring the use of the Z-5040 magnetron, the information pulses are coupled to the cathode-filament circuit through high voltage blocking condensers, thereby permitting the cavity and the waveguide to operate at ground potential, as shown in Figure 10. R-f filament chokes are selected to present a relatively high input impedance to the input circuit. Modulation sensitivity is in the order of 2.5 to 3.0 mcs/volt, requiring at least a 30 to 50 volt peak input pulse for the 250 mcs bandwidth link.

Modulation and Detection

The method of modulation and detection can be best illustrated by the series of curves shown in Figure 11. Curve D shows the klystron power mode characteristic curve along with the corresponding frequency variation

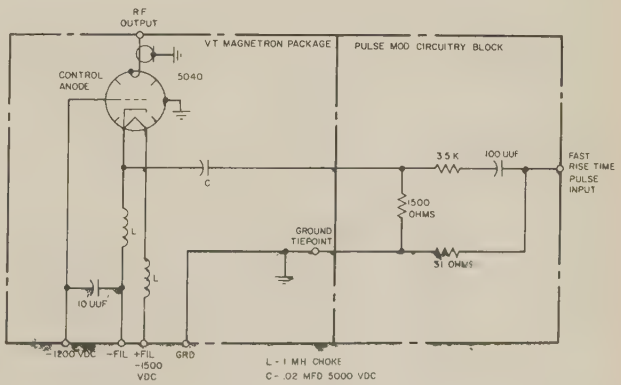

Figure 10 — VT magnetron schematic.

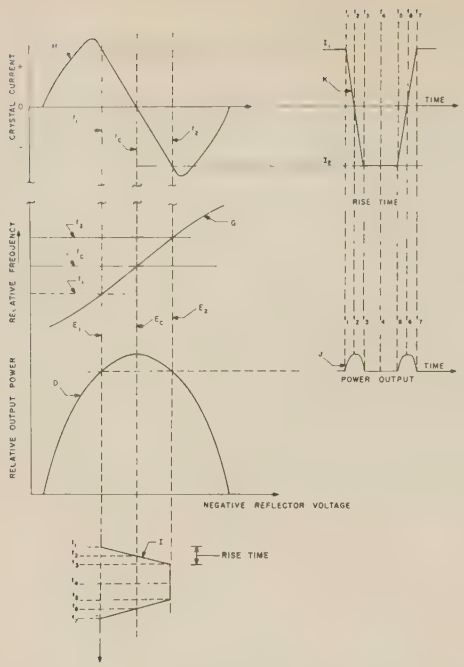

Figure 11 — Modulation and detection curves.

curve G across the mode. In addition to these two basic curves for the klystron, the discriminator curve H of the receiver has been superimposed upon the diagram so that both input and output information can be shown. This series of curves describes a typical setup of the link in which a carrier frequency f_1 is attained by adjusting the reflector voltage of the klystron to the proper value E_1.

A negative voltage information pulse I is impressed upon the reflector. This pulse is plotted versus time along a line passing through the previously set reflector voltage E_1. This line also passes through the curves for the power output D, frequency G and through the current output H of the discriminator. A negative voltage pulse I of the amplitude and time duration shown causes the power output, frequency, and discriminator output current to change as indicated by curves J, G, and K, respectively. The output current pulse K is shown ideally as a faithful reproduction of the input voltage pulse I to the system.

Several modulation techniques for operation of this link are available to the user. For example, to transmit a positive voltage information pulse, a frequency f_2 can be chosen for the carrier frequency and a positive-going current output pulse will result at the discriminator output. If, for some reason, the polarity of the output current pulse K should not be the desired direction, the tune-up of the discriminator curve H can be altered so the slope of the curve is reversed from that shown. Also, by setting up at a frequency f_c near the center of the klystron mode, both positive and negative voltage information can be transmitted through the link. It should be noted that the total bandwidth of the link, for any of the above modulation techniques, is sufficient to pass the significant r-f sidebands associated with the required pulse-risetime.

A typical tune-up for the discriminator on a 40 mcs bandwidth link yields a 30 mcs spread between peaks with a voltage change of 1.2 volts across a 120 ohm load. The 250 mcs bandwidth link tunes up with 225 mcs spread between peaks with a voltage change of 0.8 to 1.0 volts across a 120 ohm load.

Further video amplification and suitable display and recording equipment for information recovery completes the overall telemetering system.[3]

Conclusion

The 40 mcs bandwidth link, using either the klystron or the voltage-tunable magnetron, has proven to be quite reliable over distances in the order of 20 to 50 miles. The 250 mcs link, when first tried, did not prove itself as reliable. This was partly due to the stage of development at which the voltage-tunable magnetron was in at that time. Present packaging techniques and better manufacturing processes have since improved its reliability.

Generally, the wideband microwave link for telemetering has been successfully used on ground-to-ground operations where bandwidths of 40 to 250 mcs were required to measure time intervals and to reproduce pulse shapes. Transmission distances of 5 to 100 miles should be possible if proper attention is given to antenna gain and directivity to bandwidth requirements, and to transmitter power to obtain the required S/N ratio for reliable transmission of information.

Acknowledgments

Many people have been involved in developing a microwave r-f link of this complexity. Various members of the Instrumentation, Electronic Components, and Nuclear Test Departments at the Sandia Corporation are due a great amount of credit for their assistance.

Prominent among the specialists consulted at the Bell Telephone Laboratories were: H. T. Friis, W. W. Mumford, J. R. Pierce, J. O. McNalley, E. D. Reed, C. R. Moster, G. E. St. John, E. G. Olsen, H. C. Foreman, and J. P. Molnar.

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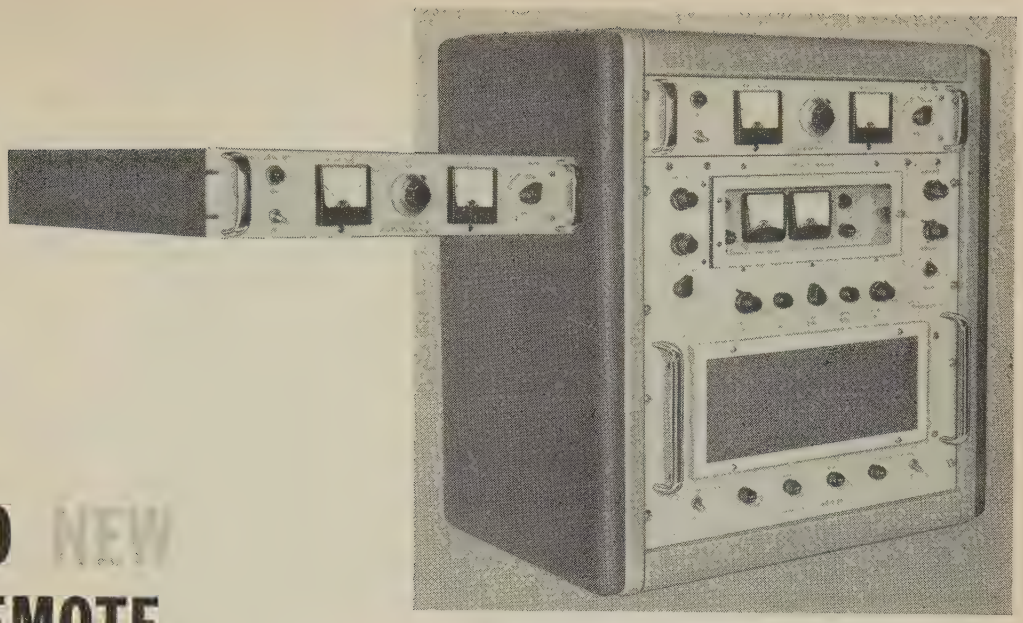


Model SS 20 Signal Source Power Supply with Tuning Unit. Tuning Unit is removed to control position for remote operation. Inset shows unit removed for remote operation. In this mode, control unit can be operated up to one mile away.

TWO NEW REMOTE TUNED SIGNAL SOURCES

(50 mc to 2 kmc, and 1 to 37.5 kmc)

Now Scientific-Atlanta offers two remote tuned signal sources which provide complete frequency coverage from 50 mc to 37.5 kmc. These sources are primarily designed for use as transmitters for antenna test ranges but find many other applications where remote tuning at distances up to a mile or more is required.

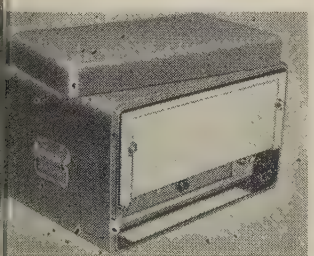
MODEL SS 30 (50 mc to 2 kmc)

Contains three GR Unit Oscillators mechanically ganged and servo driven. • RF output capable of being sine or square-wave modulated. • Frequency accurately resettable to within ±0.5%.

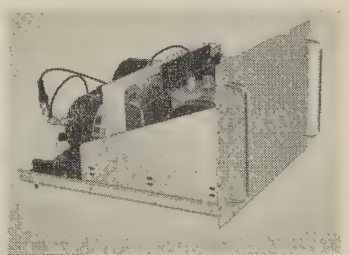
MODEL SS 20 (1 to 37.5 kmc)

Extended frequency coverage with seven Series RFO Oscillator Units. Integral-magnet backward wave oscillators are voltage tunable and require no mechanical peaking. • RF output capable of being square-wave modulated. • High signal purity, low residual fm. • Will operate cm and mm-wave klystrons. • Remote tuning unit will also operate SS 30 Signal Source.

KEY SPECIFICATIONS	MODEL SS 30	MODEL SS 20
Frequency Range	50 mc to 2 kmc	1 to 37.5 kmc
Tuning Chart Accuracy	±2%	±5%
Frequency Resettability	±0.5%	±0.1% or 5 mc, whichever is greater
Power Output	80 mw into 50-ohm load	see table of RFO Oscillators



atherproof Enclosure and a Series
) Oscillator Unit.



Model SS 30 RF Oscillator Unit

SERIES RFO OSCILLATOR UNITS

MODEL	FREQUENCY RANGE	OUTPUT POWER
RFO 1	1.0 - 2.0 kmc	40 - 800 mw
RFO 2	2.0 - 4.0 kmc	100 - 800 mw
RFO 3.6	3.6 - 7.2 kmc	5 - 300 mw
RFO 7	7.0 - 11 kmc	20 - 300 mw
RFO 8.5	8.5 - 16 kmc	5 - 100 mw
RFO 15.5	15.5 - 24 kmc	5 - 125 mw
RFO 23.5	23.5 - 37.5 kmc	5 - 100 mw

PRICES

Model SS 30, $3,850; SS 20, $3,550; SSG 1 Sine-Square Wave Generator, $350; RFO 1, 2 and 3.6, $1,400; RFO 7, $1,900; RFO 8.5, $2,060; RFO 16, $3,330; RFO 23.5, $3,330. For more details, please contact your S-A representative or write directly. Address Dept. 69

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S-A **SCIENTIFIC-ATLANTA, INC.**

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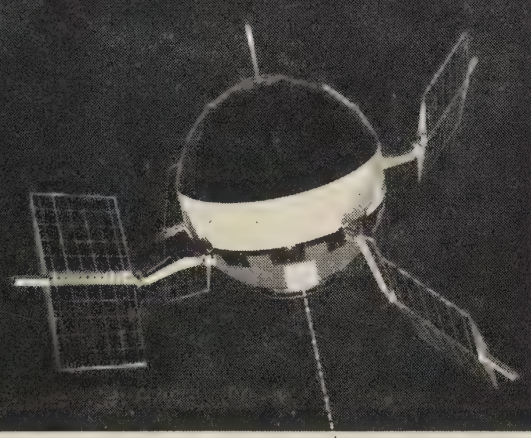
Coax Switch Successful 8,000,000 miles from Earth



Pioneer V's successful switchover from the 5 watt transmitter to the 150 watt telemetry system by a Transco "Y" Type Coaxial Switch marks a milestone in accurate and reliable switching.

PROOF POSITIVE that this and other Transco switches can always be relied upon for positive operation — even in the most severe environmental conditions. Be sure to have complete specifications on hand for your next project.

IMPEDANCE 50 ohms
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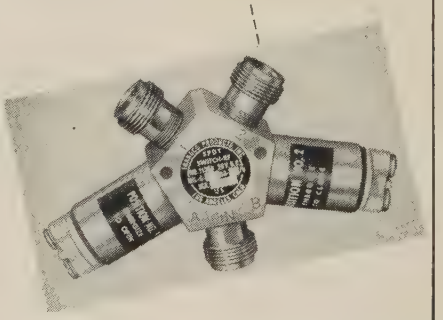
INSERTION LOSS .15 db at 5 KMC
CROSSTALK 35 db at 5 KMC
WEIGHT 6 oz.

When you have a microwave switch problem be certain you contact Transco — BECAUSE Transco is the world's largest manufacturer of microwave switches — designing and building more types of switches than any other firm.



PIONEER V PROJECT IS CARRIED OUT BY SPACE TECHNOLOGY LABORATORIES FOR THE NATIONAL AERONAUTICS AND SPACE ADMINISTRATION UNDER THE DIRECTION OF THE AIR FORCE BALLISTIC MISSILE DIVISION.

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COAXIAL SWITCHES
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Industry News

(*Continued from page 38*)

MICROWAVE ASSOCIATES, INC., INVESTS IN ANTENNA SYSTEMS, INC.

Mr. Charles W. Creaser, Jr., presider of Antenna Systems, Inc., Hinghan Mass., and Mr. Dana W. Atchley, Jr president of Microwave Associates, Inc Burlington, Mass., jointly announced a agreement between the two companie The agreement provides for a long-ter loan (5 year) by Microwave Associate to Antenna Systems in return for whic Microwave Associates receives rights t purchase up to 28% of the outstandin common stock. It is a continuing agre ment which can provide additional finan ing and technical cooperation in th future.

Antenna Systems, Inc., founded in D cember 1959, has expanded rapidly t over 70 employees. The company ha already developed a new type of lo cost 30 foot reflector suitable for a curate tracking to over 10,000 mcs an is now in volume production of a com plete tropospheric scatter antenna sy tem. The proceeds of the Microwav Associates' loan will be used to financ future expansion in the growing larg antenna field.

Mr. Atchley stated that his compan in addition to supplying financial assis ance to Antenna Systems, is currentl providing microwave engineering an production assistance, and jointly the tw companies have combined talents in th development of a radically new duplexe for tropospheric scatter use.

— *mwj* —

WALTERS NAMED BY AERO GEO ASTRO CORP.

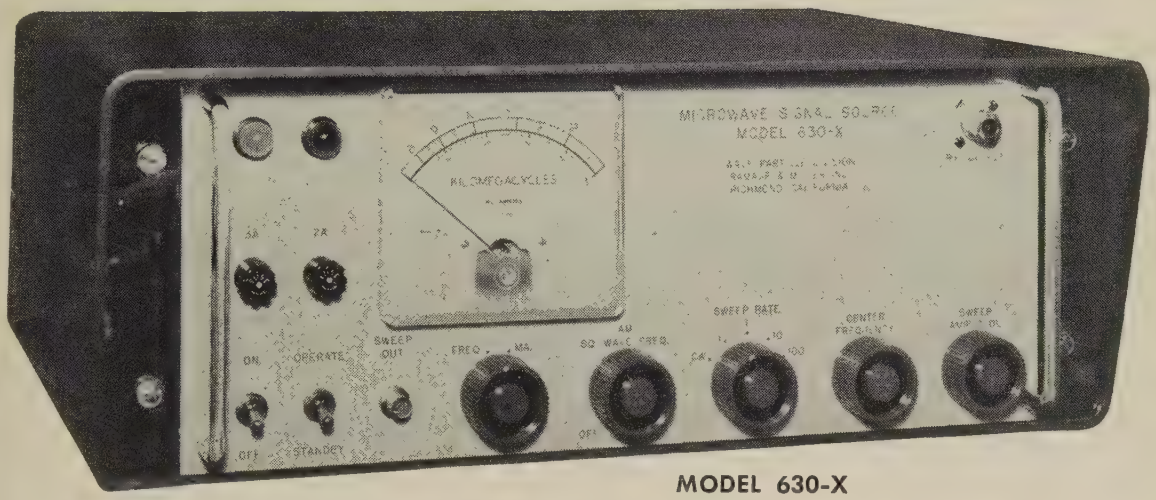
Andrew W. Walters has been name head of Aero Geo Astro Corporation Division in Corona, Calif. The Cal fornia plant performs work in recon naissance, surveillance, guidance, com munications and countermeasures. Befor joining AGA, Walters headed the Ele tronic Division of the Naval Researc Laboratory where he conducted scientif work in the fields of guided missil fusing, long range radar, submarine d tection systems and radio frequency com ponents. He has also directed researc and development programs with the Na tional Bureau of Standards and Nava Ordnance Laboratory.

(*Continued on page 80*)

X-BAND

.2-12.4 KMC

ELECTRONICALLY SWEPT SIGNAL SOURCE



MODEL 630-X

FREQUENCY:	8.2-12.4 KMC
POWER OUTPUT:	20 MW (Minimum)
SWEEP RATE:	C. W. or 0.1-100 CPS
SWEEP WIDTH:	A few MC to 4.2 KMC
A. M. MODULATION:	800-1200 CPS Sq. Wave
SWEEP OUTPUT:	Linear Sawtooth
OSCILLATOR:	Varian VA-161
SIZE:	7" x 19" x 13"
WEIGHT:	Approx. 25 lbs.
R. F. CONNECTOR:	Type "N" (Female)
PRIMARY POWER:	105-125/1/60
PRICE:	$2,850.00
RACK MOUNT:	$2,825.00
DELIVERY:	1-3 Weeks

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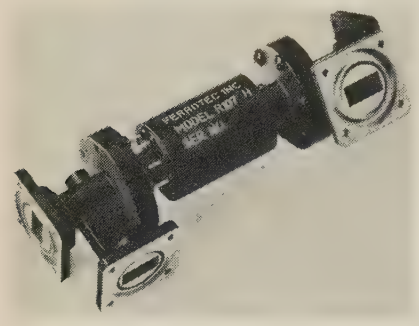
New Products

NEW FERRITE SWITCH BY FERROTEC



A new Ku-band high-power fast ferrite switch enables two microwave antennae to be time-shared by a common transmitter and receiver, maintaining high isolation between the magnetron and load.

Developed and produced by Ferrotec, Inc., Newton, Mass., the Model R-107H is the first fast-switch capable of handling peak power levels of 100 kw, at 100 watts average in the K_u Band, and can be switched at speeds under 10 microseconds. Switching is performed using less than 70 watts peak and 2 watts average power.

The Ferrotec Model R-107H fast-switch operates over a 2 per cent band between 15.7 and 16.9 kmc, with loss of only 0.5 db, maximum VSWR of 1.20 and isolation between ports greater than 20 db. The switch is operable over the full temperature range between -40°C. and +100°C.

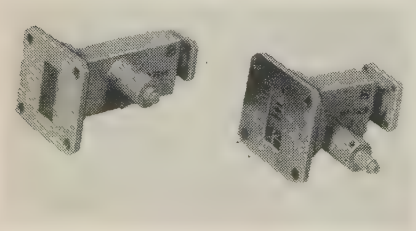
Ferrotec's high power fast-switch employs the Faraday rotation principle, using a ferrite structure between a pair of compact two-mode transducers. The output transducer is oriented 45° with respect to the input transducer.

Among additional applications of the Model R-107H are service as a high-frequency, high-power modulator and as a variable attenuator.

Circle Reader Service Card 101

— *mwj* —

NEW HARMONIC GENERATORS



Ten new harmonic generators which incorporate solid-state elements are available from Microwave Associates, Inc., Burlington, Mass. The units provide efficient generation of second, third, fourth, and fifth harmonics with output frequencies ranging from L-band (1.30 to 1.43 kmc) to V-band (53.0 to 80.0 kmc).

These harmonic generators are broadband, fixed-tuned and have filters to eliminate unwanted harmonics. They have versatile coaxial, waveguide and strip-transmission line packaging.

These models have exceptionally high output power with conversion losses well below existing devices for harmonic generation. Using high-voltage-varactors, harmonic power of 100 to 150 mw has been generated at the third harmonic in the region of 6 kmc with a conversion loss of 8 to 10 db.

In addition to the 10 models available for delivery now, new models converting 1 watt at 2000 mc to 100 mw or more at 4000 mc and 6000 mc are under development. Another model converts 1 watt at 3000 mc to 250 mw at 6000 mc.

Price, delivery, and technical information is available.

Circle Reader Service Card 102

— *mwj* —

NEW SERIES OF BROAD-BAND PULSE RECEIVERS

Development of a new series of wide open broadband pulse receivers has been announced by Granger Associates, Palo Alto, Calif. According to Dr. John V. N. Granger, president of the electronics firm, just three of these new receivers cover the entire 45 to 10,750 mc spectrum with sensitivities approaching those of super-heterodyne equipment. (Models 301, 302 and 303, shown in photo.)

Dr. Granger explains that the combination of wide-band and high sensitivity performance characteristics make these receivers ideal for intercept and analysis of pulsed signals in both airborne and ground installations.

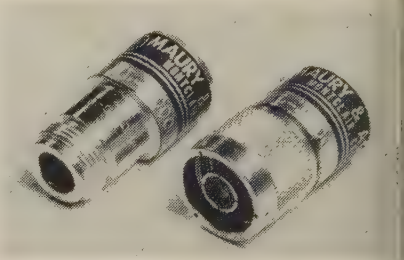
All of these receivers employ RF preamplifiers with specially designed crystal-video circuits. In the frequency range between 45 mc and 550 mc, stagger-tuned preamplifiers are utilized. Above 550 mc, permanent magnet-focused traveling wave tubes are used to obtain RF preamplification. The video amplifiers are completely transistorized, as are their power supplies. Output of each channel is separately available for video analysis, and — stretched form — for recording. Provisions for blanking are also included.

The receivers are available in either relay rack or standard aircraft ATR packaging. Power requirements are 105 to 121 volts ac; 50 to 800 cps for rack mounted versions and 360 to 800 cps for airborne versions. ATR cases are provided with stock trays. Rack mounted packaging is for standard 19 inch relay racks.

Circle Reader Service Card 103

— *mwj* —

MATCHED COAXIAL TERMINATIONS INTRODUCED BY MAURY & ASSOCIATES



Maury & Associates, Montclair, Calif. has introduced a new series of coaxial type N terminations. Small in size, the new units have a characteristic impedance of 50 ohms nominal, a maximum VSWR of 1.05 in the range dc to 1000 mc, and a power capability of 1 watt cw.

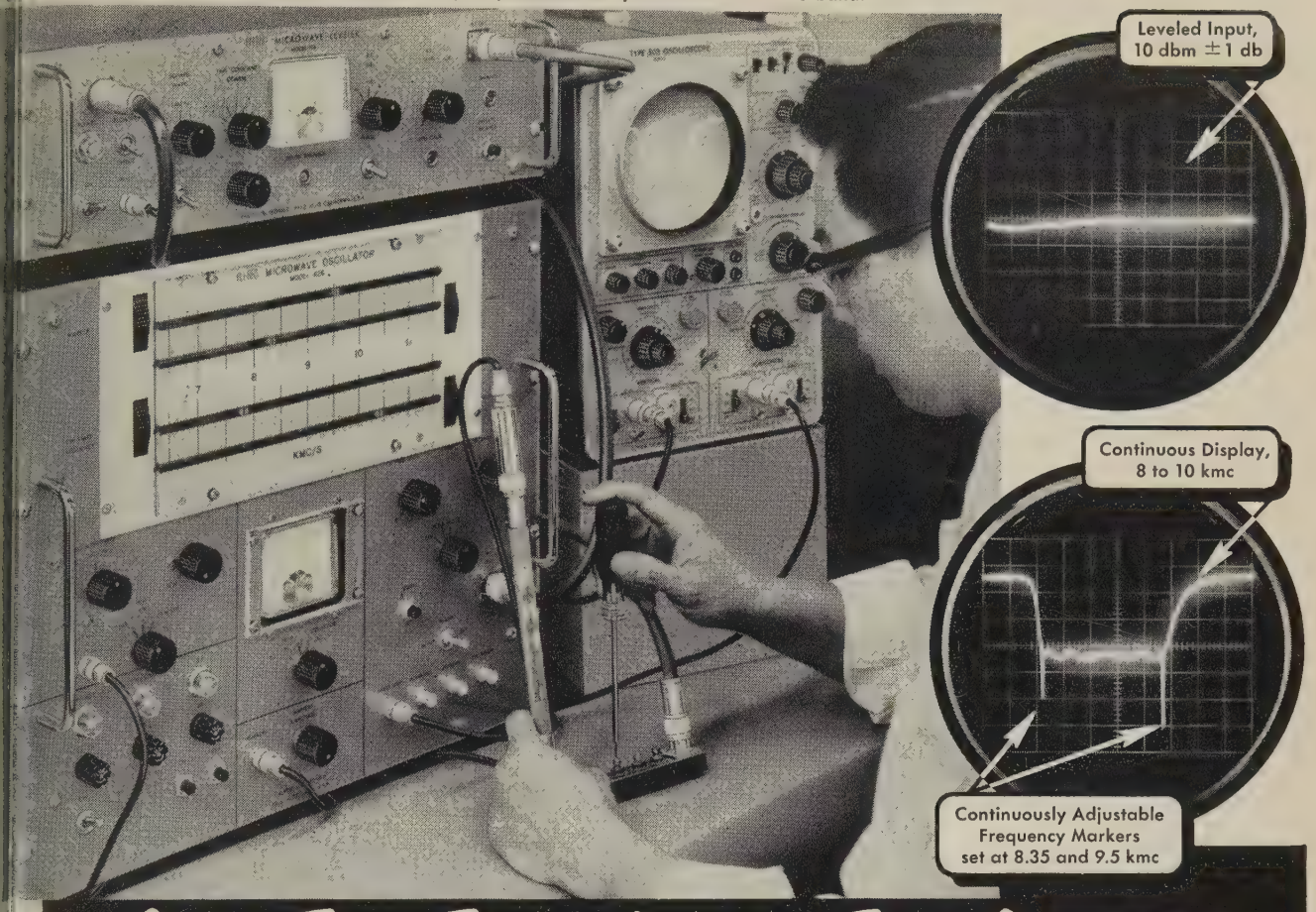
Available with either male or female connectors, the terminations have a unit price of $27.50.

Circle Reader Service Card 104

— *mwj* —

(*Continued on page 68*)

g insertion characteristics of X-band filter with Alfred Swept Generator. It consists of Alfred wave Oscillator and Alfred Microwave Leveler. This combination electronically sweeps frecy linearly with respect to time while maintaining RF power virtually constant across the band.



Save Test Time, Assure Test Accuracy

with ALFRED'S new SWEPT Microwave Generator.....

The scope patterns tell the story. Top pattern shows constant power input from Alfred Swept Generator to component (filter) under test. With known input, variation in output is due to filter characteristics. Lower pattern is especially significant, showing continuous, flicker-free display, 8 to 10 kmc. Any changes in stubs or irises are immediately reflected. Measurement accuracy is assured *at every frequency*, not just at selected points.

S TECHNIQUE CAN BE USED FOR MOST PRESENTLY KNOWN MICROWAVE TESTING PLICATIONS. HERE'S WHY IT'S FASTER THAN CONVENTIONAL SIGNAL GENERATORS:

Continuous Display allows immediate easurements—no plotting needed. ace can be recorded if desired.

Sweep Technique eliminates time-conming "point-to-point" frequency and wer setting methods of conventional nal generators. Sweep range is continusly adjustable with 1% accurate Direct ading Slide Rule Dial.

"Quick Look Readout" eliminates calations in setting sweep range.

Adjustable Frequency Markers allow pid, broadband calibration of scope or corder trace.

SOME MORE FACTS YOU SHOULD KNOW

* *Frequency Ranges.* The Swept Generator is available in five ranges to 12.4 kmc—1 to 2, 2 to 4, 4 to 8, 7 to 11, 8.2 to 12.4.

* *Stability.* At any single frequency, stability of the Swept Generator equals that of a conventional signal generator. Spurious modulation is low.

* *Power Output.* Greater than a signal generator: 10 milliwatts as compared to 1 milliwatt.

FUNCTION OF THE LEVELER It holds power output constant to ±1 db over standard frequency ranges, and better than ±1 db over narrower ranges. The Leveler serves as a broadband attenuator with up to 20 db dynamic range control, providing constant output over a wide range. It can be used as a general purpose instrument for a wide variety of oscillators and amplifiers.

For more details on the Alfred Swept Generator—please contact your Alfred sales engineering representative, or write direct.

See Us At WESCON Booth 630

y specifications for Signal Generators available for coverage from 1 to 12.4 kmc

equency—Controls: Continuously adjustable with direct calibrated dial. Calibran accuracy: 1%. Stability: ±0.02%/hr. Residual FM: ±0.0025%. **Power Output inimum)**: 10 mw ±1 db. Continuously adjustable from zero to maximum. **enuation Range**: Up to 20 db. **Sweep**—Selector: Recurrent Sweep, Single Sweep, gle Frequency, and External on panel switch. Time: 100 to .01 seconds, conuously adjustable. **Monitor Output**—Sweep Out: Positive linear sawtooth, 45 ts peak. Panel BNC connector. **Amplitude Modulation**—Internal Square Wave: output is alternately 0 and unmodulated CW value. Frequency 800 to 1200 cps, justable by panel control.

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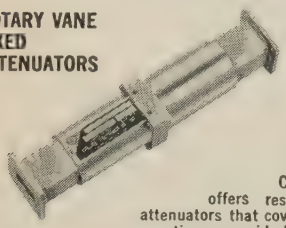
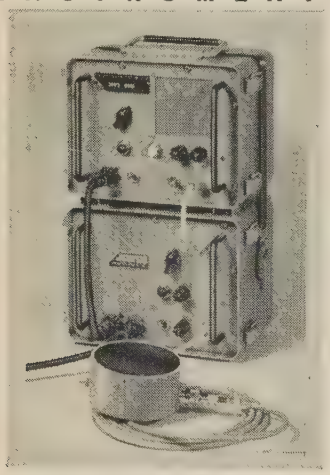
MICROWAVE COMPONENTS

ROTARY VANE FIXED ATTENUATORS



C.E.C. offers resistive attenuators that cover an entire waveguide band. These attenuators maintain a flat attenuation charactertistic over their entire waveguide band. ATTENUATION: 3 db, 10 db or 20 db are offered as Standard. Other attenuation values can be preset to your specifications.

INSTRUMENTS



VHF-UHF FREQUENCY CALIBRATOR MODEL 121

Range: 50 mc to 11,000 mc in crystal controlled steps of 50 or 100 mc.

Output Level: In excess of —70 dbm minimum for all markers.

Accuracy: ±0.005% at any frequency, unaffected by temperature or power input variations.

HARMONIC MULTIPLIER AMPLIFIER ADAPTER

Output Waveform: CW or Pulse.

Output Level: increases amplitude to —30 dbm in frequency range from 1,000 to 11,200 mc with marker spacing of 1,600 mc. Lower amplitude (—60 dbm) markers are generated with a spacing of 400 mc.

BROADBAND ANTENNA

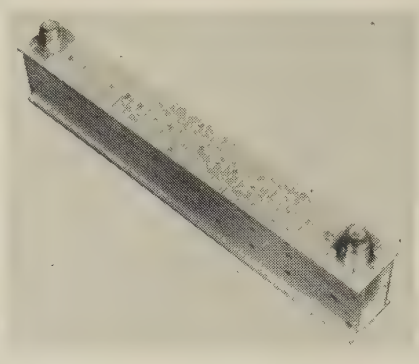
Designed for use with the Harmonic Adapter, this broadband antenna covers the entire range from 1,000 mc through 11,200 mc.

Used in combination, the three units provide a fast go-no go, remote calibration check on aircraft radar receivers, without the need for connecting cables to the aircraft.

CONTROL ELECTRONICS CO., INC.
Ten Stepar Place, Huntington Station, N.Y.

(*Continued from page 66*)

BAND-PASS CHARACTERISTICS OF NEW CAVITY FILTERS MAY BE ADJUSTED BY HEX-SCREWS



Telonic Engineering Corporation, Laguna Beach, Calif., is now offering a new type of adjustable, multi-section band-pass filter. The new units are available with center frequencies ranging from 200 to 2400 mc. Bandwidths may be varied, by simple hex-screw adjustments, from 1.5 to 10 percent or more of the center frequency.

The new Telonic ACF Cavity Filters are finding widespread application as fixed-tuned pre-selectors, or in uses such as harmonic suppression or selection on the output of fixed-frequency oscillators. The adjustable bandwidth feature makes the units ideal for development laboratory applications, although the small size, rugged construction and high, 100 watt, power rating of the filters also makes them adaptable to a wide variety of commercial and military uses.

The Telonic ACF filters are available with two to nine cavities. Insertion losses range from .5 to 3 db, depending on the bandwidth and rejection characteristics. The construction consists of silver-plated brass parts, machined to close tolerances to assure stability and uniformity of electrical characteristics. This construction also accounts for the unusually high power rating of the units.

The frequency of each cavity section is tuned by means of an inductive plunger with a recessed hex screw adjustment. Adjustable inductive loops are used for input and output coupling. Interstage coupling is adjustable by means of a variable capacity. All of these adjustments are set at the factory to produce the desired band-pass characteristics, but may be re-tuned with an Allen wrench and screwdriver over a considerable range.

Input and output impedances are normally set at 50 ohms, although 75 or 93 ohm units are available. Connectors are normally BNC, although TNC and Type N connectors are available.

Circle Reader Service Card 105

— *mwj* —

MODULAR MICROWAVE COMPONENTS KITS AVAILABLE FROM SANDERS ASSOC.

Standard kits of modular microwave components are now available as a design tool to facilitate breadboard and prototype designs using the Tri-Plate® strip transmission line by Sanders Associates, Nashua, N.H. The kits range in size, variety of components and number of components, and are available for immediate delivery in L-Band, S-Band, C-Band and UHF.

There are four standard kits in each of the frequency bands. They range from the basic laboratory kit to a kit of components capable of building up a highly complex circuit such as: multiple channel mixers, complete front end, matched power dividers, microwave computer logic and many other circuits involving the use of hybrid rings, directional couplers, tees, impedance transformers, coax transitions, crystal mounts and terminations.

In addition to these standard kits, Circuit-mated kits are furnished to specifications of any circuit, for specified modifications of that circuit, or for several circuits. The Circuit-mated kits are made up to order from on-the-shelf modules to meet electrical and mechanical specifications and circuit diagrams.

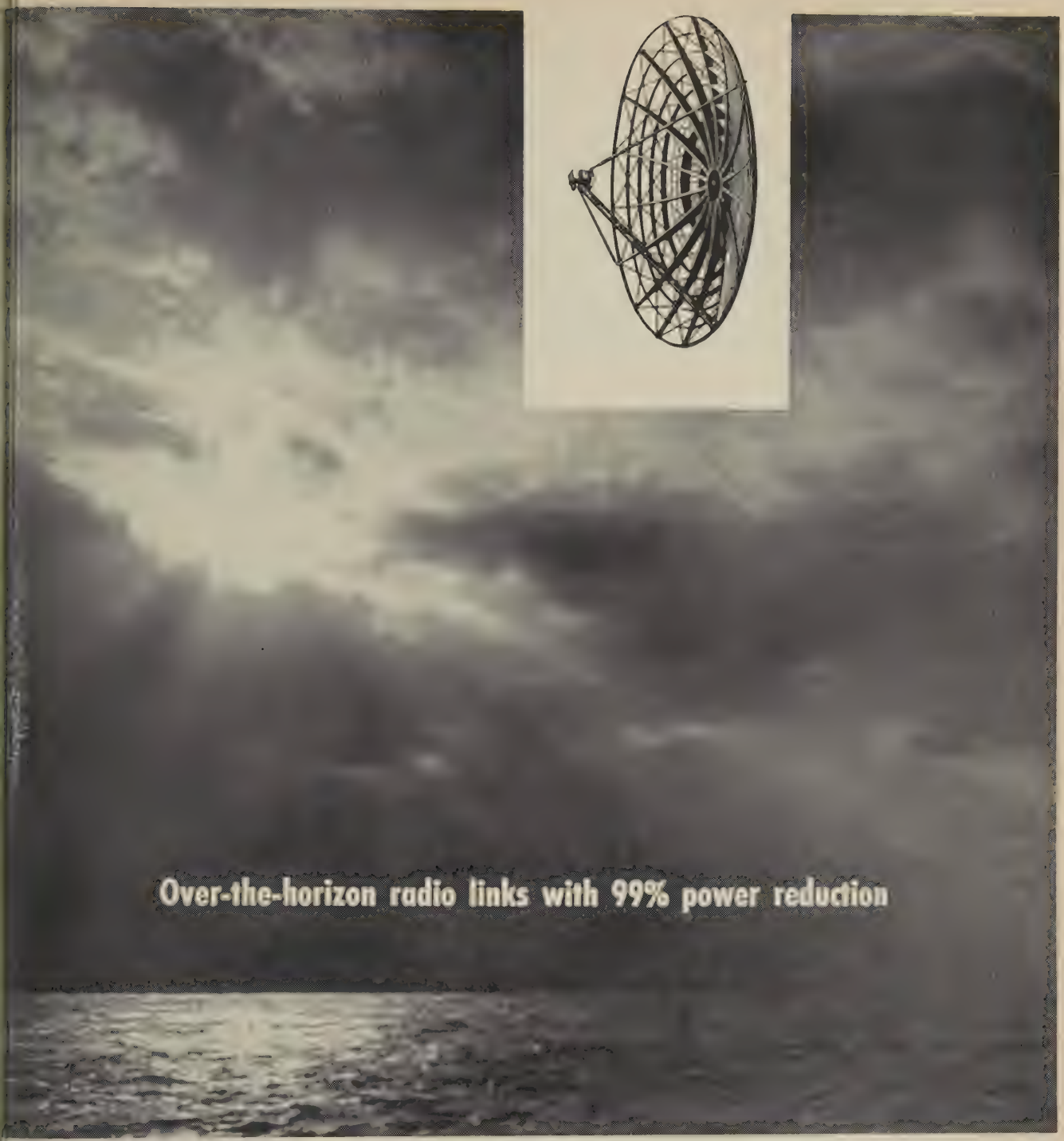
A typical standard kit for S-Band, Kit S-2 shown in the photograph, contains the following components: four transitions to type N female connector; one, 3 db directional coupler; one, 20 db directional coupler; one, hybrid ring; one, two-way power divider; one transformer 25-50 ohms; three crystal mounts; three, 50 ohm terminations; and two straight sections. This kit is priced at $945 and is available from stock.

Prices of the standard kits range from $645 for the basic laboratory kit to $2,190 for the largest size standard kit.

Circle Reader Service Card 106

(*Continued on page 70*)

— *mwj* —



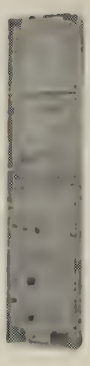
re is an important new advance in microwave communications NEC's High Sensitivity Reception system. By combining high nsitivity reception, parametric amplifier, low feeder loss design, d the high antenna gain possible at 2000 mc, this system proves S/N ratio by more than 20 db.

is permits hops at 1/1000 of the power required for conven-nal links. For example, a 400 W OH-2000 using a 33-ft dish d quadruple diversity is capable of a 300-mile hop at 99.0% iability, or 99.9% reliability at 260 miles.

e OH-2000 is drastically reducing installation and maintenance sts of over-the-horizon links in capacities up to 60 voice chan-is. A descriptive brochure is available on request.

OH-2000 in military communications

First major OH-2000 installation will be a 17-station system for the United States Air Force linking radar sites on the three main islands of Japan. The system contains no active repeaters. Longest hop is 145 miles at 100 W output. Guaranteed reliability is a character error of no more than 1:10,000 for 99.9% of a year's hours.



OH-2000

The compact 100W transmitter uses economical planar tubes in the final stage. A quadruple diversity station requires a radio room of only 100 Sq. ft. NEC can also supply completely transistorized carrier equipment.

NEC *Nippon Electric Company Ltd.* Tokyo, Japan

Components / Systems

Circle Reader Service Card 38

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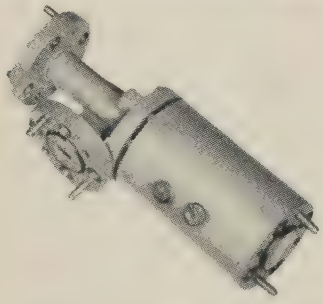
INCORPORATED

MICROWAVE HARDWARE 30-140 KMC

Available for 60-75 KMC from stock or to your specifications.

EXCLUSIVE



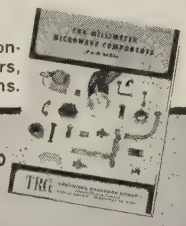
FERRITE HIGH-POWER RECIPROCAL SWITCH

The light-weight Model V-FSW2 switches an input signal to either of two output ports in approximately 2 microseconds. Power handling capacity is at least 10kw peak, unpressurized. For RG 98/U waveguide, standard UG 385/U flanges.

SPECIFICATIONS FOR 3% BAND:

VSWR:	<1.25	Current:	180 ma (nominal)
Insertion Loss:	<1.0db	Length:	3"
Isolation:	>20db	Pressurization:	30 psi

WRITE FOR NEW CATALOG 160A for details on Ferrite Components, TE_{01} Mode Circular Waveguide Components, Hybrid Mixers, Crystal Holders, Feed Horns, Dishes, Electroformed Transitions.



TRG INCORPORATED
ANTENNA & MICROWAVE DEPT.
9 Union Square, Somerville 43, Mass. • MOnument 6-8680
TECHNICAL RESEARCH GROUP
Syosset, New York • Somerville, Mass.

Circle Reader Service Card 39

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TO YOUR SPECIFICATIONS
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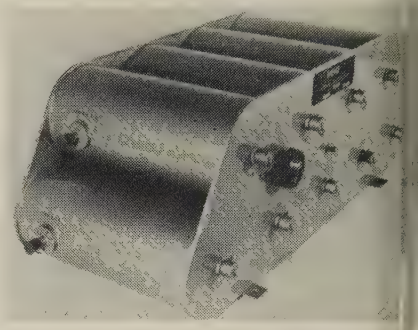
Circle Reader Service Card 40

New Products

(*Continued from page 68*)

RANTEC ANTENNA MULTIPLEXER



The Model MT-395 antenna multiplexer offered by Rantec Corp., Calabasas, Calif., provides high degree of isolation between transmitters and/or receivers with low RF loss. Unit consists basically of three highly selective band-pass filters and a combining network. Each filter is composed of three very high Q coaxial cavities, series coupled and resonant on the same frequency. MT-395 has the following general specifications: low frequency channels — 225 to 260 mc, high frequency channels — 260 to 300 mc, isolation — greater than 60 db with 10 mc separation, insertion loss — 0.7 db maximum, VSWR — 1.5:1 maximum and pass band — ± 750 kc minimum.

Electrical specifications can be varied for specific applications. Delivery approximately 60 days.

Circle Reader Service Card 107

— *mwj* —

NEW PARSONS MICROPULSE DELAY LINE

The Ralph M. Parsons Company, Electronics Division, Pasadena, Calif., announces a new miniature lumped-constant delay line with a wide variety of general applications.

These high-density units are available in two standard configurations; cylindrical with a nine-pin header for standard tube socket mounting, and rectangular for use with printed circuitry. Small in size and lightweight, Parsons Micropulse delay lines are for use where space and weight are critical. The cylindrical model is 1.0 inch in diameter by 2 inches long, and weighs 1.5 to 2.0 ounces depending on required delay. Volume and weight of the rectangular models are comparable. Units are completely potted and fabrication techniques permit volume production.

Units having delay times of 0.5, 1.0

(*Continued on page 71*)

Short Term Frequency Stability measured with High Accuracy

THE AIL TYPE 392B

Frequency Stability Tester for Checking Drift, Jitter, Jitter rate

- *Checks L- and S- band oscillator performance*
- *Responds to input levels as low as —45 dbm*
- *Checks frequency stability to 1 part in 10^9.*

It is particularly useful for the measurement of MTI Stalo stability during the short time interval when Stalo drift may cause erroneous target information. It operates in the approximate bands of 1120 to 1700 mc and 2600 to 3200 mc. The AIL type 392B provides rapid design and production checks. Compact, lightweight and portable it is ideal for field testing.

Write for descriptive literature.

AIRBORNE INSTRUMENTS LABORATORY
DEER PARK, LONG ISLAND, NEW YORK
A DIVISION OF CUTLER-HAMMER, INC.

New Products

(*Continued from page 70*)

2.0, and 3.0 microseconds are available off-the-shelf. The total delay is accurate to ±3 per cent. The rise-time to delay-time ratio is 5 per cent with an attenuation of 1 db. Leakage resistance is more than 100 megohms between line and ground at 500 volts dc. Input impedances available are 300, 500, and 1,000 ohms, ±10 per cent.

Many modifications of standard units are available for special applications, including other header arrangements, delay times, input impedances, or as many as six taps.

This new Micropulse delay line is priced competitively with other lines and is available for immediate delivery.

Circle Reader Service Card 108

— *m w j* —

WORLD'S SMALLEST LOAD AVAILABLE

Transco Products, Inc., Los Angeles, Calif., announces the smallest load currently available for energy absorption is now ready for immediate delivery. Overall size of the Load, including Type N Connector, is 1.16 inches — adds only .65 inches beyond connector.

Other specifications are: impedance — 50 ohms, VSWR — 0 to 1200 mc, 1.04 maximum; 1200 to 2000 mc, 1.1 maximum; can be supplied to meet specific bandwidth requirements from 2 to 10 kmc. Power — average 1 watt, peak 1 kw. Operating temperature -65° to +250°F. Weighs just 1.5 ounces.

Circle Reader Service Card 109

— *m w j* —

(*Continued on page 72*)

Circle Reader Service Card 41

ANTENNAS by Ainslie CORPORATION

Pedestal Model 1010 shown

NOW — available from Ainslie Corporation, a new remote control positioning pedestal capable of handling our antennas up to 18 feet in diameter in frequencies from 100 to 10,000 mc. Modifications available for a variety of tracking applications. Whatever your antenna or reflector requirements may be, contact us at our new facilities.

Ainslie CORPORATION

531 Pond Street
South Braintree 85, Massachusetts

Circle Reader Service Card 42

NO. 2 OF A SERIES

Is Purchase Price the True Cost of an Instrument?

We all know that buyers in our industry are more price conscious today than ever. Certainly concern for price is vital if a company is to survive in a competitive market.

However, a few words of caution are in order. It is a mistake for a buyer to depend too heavily on a comparison of price lists in making a buying decision. The true cost of an instrument is not the purchase price, but the total amount spent on an instrument over its life. This includes not only the purchase price, but all expenditures for maintenance and repair as well as the expense of whatever "down-time" is required.

Thus, the experienced buyer will look beyond the price lists and consider the reputation of the various manufacturers and the quality of service their instruments have given to other purchasers.

Although we strive to manufacture our instruments as efficiently as possible and are constantly seeking legitimate economies in materials and methods, we usually find that our price for a particular instrument is higher than that of some of our competitors. Yet, in terms of value per dollar, we believe that our instruments are an excellent buy. We attribute this largely to our program of quality control.

All equipment produced by us is tested 100% for compliance with specifications before we ship an instrument. We retain master copies of test data and use them for compiling statistical data on quality and as a basis for improving our specifications. Test and calibration equipment is carefully checked at prescribed intervals to assure maximum reliability. We do not rely on spot quality control; we test every piece of equipment we manufacture.

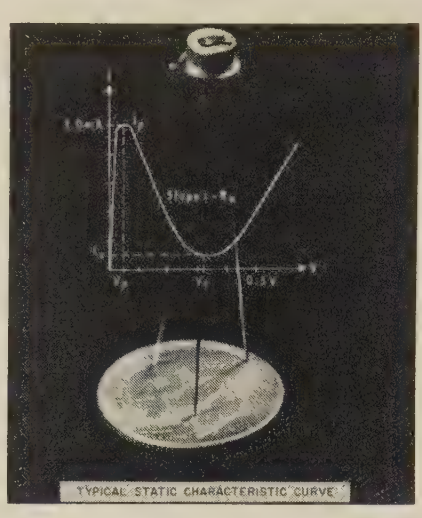
A quality control program of this depth costs money. In fact, our cost accounting indicates that over 30% of the man-hours required to produce an instrument are devoted to quality assurance.

This expenditure is reflected in our prices. It is also reflected in the lasting service our instruments render. Ask our customers.

New Products

(*Continued from page 71*)

PHILCO CUTS TUNNEL DIODE PRICES 50% — INTRODUCES NEW UNITS



Philco Corporation has reduced the unit price of its tunnel diodes introduced last March from $10.00 to $5.00 and has introduced a new tunnel diode series, it was announced by William F. Maher, manager of Semiconductor Sales for the Lansdale Division, Lansdale, Pa.

The 50 percent price cut has been made possible by improved yield brought about by more precise and stabilized fabrication processing.

The reduced units are designed for application in radar, microwave radio relay, satellite communications and computer systems. They feature a low series inductance of one millimicrohenry and a low series resistance of 1 ohm with peak to valley ratios of 5 to 1 and 10 to 1.

The new series being introduced are hermetically sealed germanium tunnel diodes designed for low level switching and small signal applications such as in special counting circuitry. Peak point current is closely controlled providing a peak to valley ratio of 8 to 1. Typical performance shows peak voltage of 55 millivolts and a valley voltage of 320 millivolts.

Like their forerunners, the new units also exhibit low series inductance of one millimicrohenry and low series resistance of one ohm.

Measured frequency of oscillation is over 1500 mc. The new diodes are packaged in shortened, hermetically sealed transistor cases having thin bases and alloy contacts and featuring a specially designed outer tab of triangular configuration.

The new tunnel diodes are available for immediate delivery at $5.00 per uni in limited quantities.

Circle Reader Service Card 110

— mwj —

NEW TWT'S FROM LITTON

Two new metal and ceramic PPM focused X-band traveling wave tubes ar now in production at Litton Industries Electron Tube Division, San Carlos Calif.

Suited to operate in series as an am plifier chain, these two tubes, designate L-3266 and L-3236, cover the frequency band of 7000 to 11,000 mc with minimun saturated CW power of 20 milliwatts and two watts, respectively. Each tub provides small signal gain in excess o 33 db.

Both tubes weigh less than four pounds each and are about 12 inches long, in cluding their shielded, temperature-com pensated, periodic permanent magnets.

The L-3266 and L-3236 are suitable for use in ECM repeaters, radar-target enhancement systems, frequency diversity radar transmitters and equipments re quiring general purpose microwave am plifiers.

Application-oriented design simplifies power supply requirements for these new traveling wave tubes. Because the collector, helix and anode all operate at ground potential, the only voltages required are for the heater, cathode and grid. A separate BNC connector is provided for the application of helix modulation.

Reliable operation and long life are characteristics of these new traveling wave tubes due to their high temperature processing.

High manufacturing yield has resulted in performance far beyond the minimum specifications as well as low prices for PM focused traveling wave tubes.

Data sheets and applications information will be supplied upon request.

Circle Reader Service Card 111

— mwj —

GLASS-ENCLOSED RESISTOR

A new type of glass-enclosed, precision film resistor has been put into mass production by Corning Electronic Components, a department of Corning Glass Works, Corning, N.Y.

Developed last year, the NF resistor has been available until now only in limited quantities. It has been used in

iaturized missile, computer, high fre-ncy, radar, switching and other cir-s requiring exceptional performance.

he glass enclosure is hermetically -d; the resistor has zero moisture ab-tion. A tin-oxide film, fired into the ace of glass rod, gives the NF out-ding ability to endure heat, humidity repeated overloads, according to the ufacturer.

he NF-60 and NF-65 are ⅛ watt ¼ watt models, respectively, having sistance range of 100 ohms to 360 K ms. Voltage ratings are 250 and 300 v ectively. Derating is to 150°C.

he NF's exceed performance charac-stics of Mil-R-10509C, Characteristic Corning guarantees characteristics in nection with load life, temperature ficient, terminal strength, moisture re-ance, temperature cycling and low perature exposure.

he smaller size, the NF-60, is about 32 inch long and less than 5/32 inch iameter.

Circle Reader Service Card 112

— m w j —

X-BAND VIDEO DETECTOR

n X-band video detector microwave de for use in radar, communications tems, countermeasures and other mi-wave applications has been announced Sylvania Electric Products Inc.

Marvin E. Groll, product sales man-r — microwave diodes for Sylvania's niconductor Division, said the new de (Type IN31A) developed on a . Army Signal Corps contract, meets full range of military environmental ts, including temperature cycle, shock, ration, centrifuge and moisture resist-ce.

Type IN31A is a high temperature 50°C) hermetically sealed diode in a axial package. It has a figure of merit 200 minimum at 9375 mc and a video pedance range of 3000 to 17,000 ohms, cording to Mr. Groll.

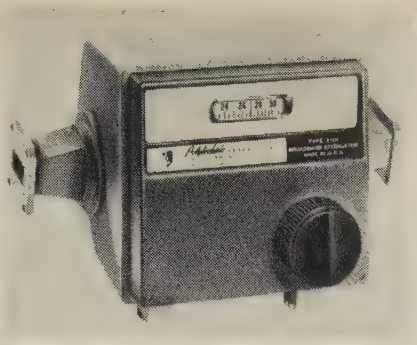
Circle Reader Service Card 113

— m w j —

BROADBAND DIRECT READING ATTENUATORS

A new series (PRD Type 101) of oadband Direct Reading Attenuators the rotary vane type is announced by D Electronics, Inc., Brooklyn, N.Y., nufacturer of microwave and electron-test equipment.

Covering the frequency range of 3.95



to 40 kmc in nine broadband models, these direct reading attenuators have an attenuation range of 60 db and a maximum VSWR of 1.15. The value of attenuation is determined by the angular position of a resistive film with respect to the waveguide and, therefore, is essentially independent of frequency.

All nine units feature unusually small insertion length, 60 db range, tape readout, built-in height adjustment, compact size and low insertion loss.

Free descriptive literature is available.

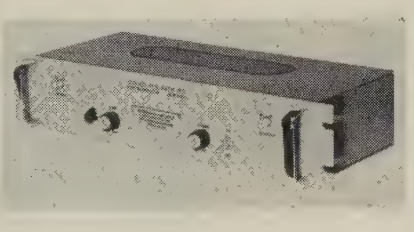
Circle Reader Service Card 114

— m w j —

VHF AMPLIFIER HAS THREE OCTAVE BANDWIDTH

Applied Research Inc., Port Washington, N.Y., announces the availability of its Model HFW-5(C)-326 Amplifier, which provides better than three octave coverage, 20 db gain and low noise figure. The amplifier combines ruggedness, simplicity and power economy, and is supplied on a panel for standard rack mounting.

Synchronous tuning, low source and output impedance and optional power supply are features of the new amplifier. Frequency range is 30 mc to 265 mc, gain is 20 db, overall noise figure less than



8 db. Using only five tubes, the power requirements are 22½W anode power, 9½W tube heater power. Dimensions of the unit, without power supply, are 19 inches long x 3½ inches high x 6½ inches deep; weight is 7¼ pounds.

Circle Reader Service Card 115

— m w j —

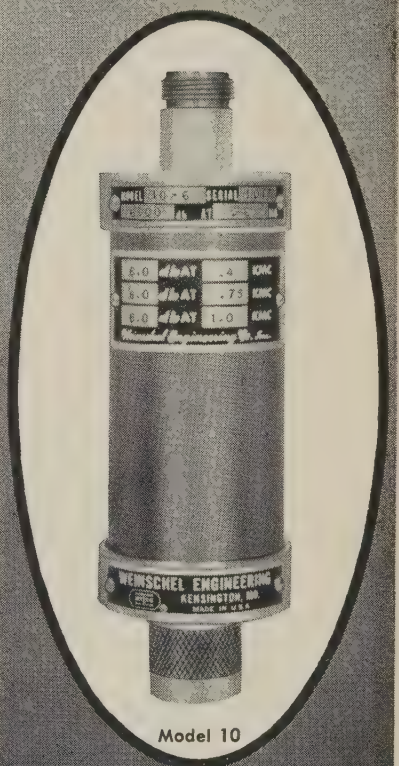
(*Continued on page 75*)

WEINSCHEL

10 WATT POWER PADS Model 10

DC to 1 KMC
Attenuation: 1 to 20 db
50 Ohms

Connectors: Type N, 1 male, 1 female
High stability, low frequency sensitivity
Power Sensitivity: Less than .1 db/10 watts
Calibration Frequencies: DC, 400 mc, 750 mc, 1000 mc
Finish: Stainless steel connectors; black anodized aluminum body



Model 10

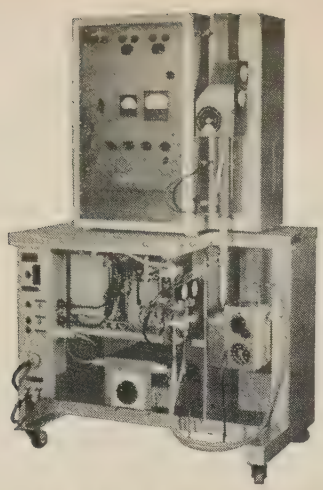
Complete specifications upon request.

WE CO

Weinschel Fixed Coaxial Attenuators cover the frequency range of DC to 12.4 KMC. Write for complete catalog.

Weinschel Engineering
KENSINGTON, MARYLAND

Circle Reader Service Card 44



UNIQUE VERSATILE COMPLETE microwave dielectrometer

Measures dielectric constant and loss over a wide temperature range at 1, 3, and 8.5 kmc.

With a complete line of accessories the Central Research Laboratories Dielectrometer gives high accuracy and unequalled versatility.

Accessories now available: *Temperature Control Unit.* Enables dielectric properties of solids to be measured at any temperature between −30°C and +500°C; liquid samples to +150°C. Includes waveguide extension and sample holders for solids and liquids.

Room-Temperature Extension Sample-Holder. For measuring liquids or semi-solids at room temperature only.

Quarter-Wave Spacers. Accurately-cut, low-loss quarter wave spacers to make open-circuited measurements or gain greater sensitivity with thin samples.

For brochure giving details and specifications, write:

Central Research **laboratories, inc.**

Dept. 203 — Red Wing, Minnesota

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M | S

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11901 Inglewood Ave. — Hawthorne, Calif.

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THE FINEST QUALITY BRASS AND ALUMINUM STANDARD WAVE-GUIDE FLANGES in stock at Formcraft—all precision made to military standards. For rigid and flexible waveguides.

Special flanges to your specifications. Send sketch or blueprint for a quotation.

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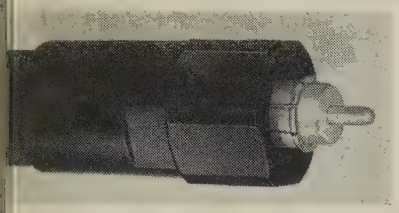
w Products

(*Continued from page 73*)

IIGH VOLTAGE MICROWAVE AXIAL RF CABLE CONNECTORS BY TAPCO



he Tapco Group of Thompson Ramo oldridge, Inc., Cleveland, O., an- nces the development of an Lt series high voltage microwave coaxial RF le connectors.

hese connectors are designed for nsmission of high power RF energy airborne electronic systems. They are designed for straight and right angle figurations and have a frequency ge of 50 mc to 5000 mc with a power dling capability of 1000 watts. ough presently designed for RG-119/ RG-209/U and RG-211/U coaxial ca- , they can be modified for other es.

Made of light-weight aluminum con- ction and capable of operating under ditions including 70,000 feet altitude temperatures ranging from -54 C to 5 C, these connectors have a special sture seal in the mated and unmated ditions. A sliding coupling nut per- s complete mating prior to thread gagement. The cable grips are easily ached.

Circle Reader Service Card 116

— m w j —

GH-POWER ABSORBER CERAMICS OR MICROWAVE APPLICATIONS

Ceramics for Industry, Mineola, N.Y., nnounces that a new microwave ab- rber ceramic, CFI Body Series 1000, is w available in commercial quantities. he high-power CFI 1000 ceramics are well suited for use by microwave engineers working over a broad frequency range for high and low power applications.

A typical high-power absorber ceramic, CFI-1003, exhibits high losses of 9.05 db/cm at 25°C and uniform attenuation over a wide range of frequencies. In addition, CFI-1003 is stable in air or vacuum at high temperatures in excess of 1000°C in both low and high power systems.

These microwave absorber ceramics are now being used in mode suppressor, level-set and variable attenuators and termination applications.

Ceramics for Industry is a manufacturer of engineered precision ceramics and ceramic-to-metal assemblies.

Circle Reader Service Card 117

— m w j —

DISC THERMISTORS IN DIODE CANS FOR EASY MOUNTING

Fenwal Electronics, Inc., Framingham, Mass., announces it has packaged disc thermistors in diode cans. This conventional, easy-to-use type of mounting, assures good thermal contact with sink surfaces. Discs of high-power handling capacity in resistance from 5 ohms to 11,000 ohms, can now be quickly and ruggedly secured to chassis and surfaces with a minimum of design mounting problems.

Besides providing accurate and fast surface temperature sensing for indication or control, these diode cans can be mounted near transistors and compensate for thermal limitations, thereby extending the useful range of transistor circuitry. The mount can also be electrically and thermally insulated from the mounting surface and provide easy mechanical attachment for other applications.

Circle Reader Service Card 118

— m w j —

(*Continued on page 76*)

PAPERS

We wish to emphasize again that "the journal" is interested in receiving papers from the industry.

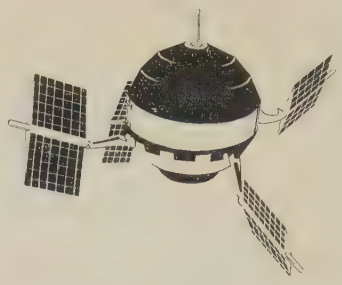
Papers can be addressed to:
"the microwave journal," 1330 Beacon St., Brookline, Mass.
In the West Coast Area please address all papers to:
"the microwave journal," Box 1134, Palo Alto, California.

— m w j —

CHANGE OF ADDRESS

When requesting a change of address, please furnish the latest address at which you received *the microwave journal.* Allow one month for the change to become effective.

SOLID STATE FRONTIERS



TRACKING DOWN A WHISPER AT 20,000,000 MILES

Keeping in touch with satellites in their solar orbits calls for detection of the last faint whisper of available signal strength. At ranges approaching 20,000,000 miles, the conservation of only 0.1 db in signal may add another 200,000 miles of closed contact.

At these extraterrestrial boundaries, optimum stabilization of parametric amplifier gain with antenna mismatches takes on critical importance, and utilization of the non-reciprocal properties of ferrite isolators to achieve this stability – without introducing excessive loss – appears indispensable.

For the Pioneer V, currently breaking all long-distance communications records, compact UHF isolators, developed by Motorola, provide this important assistance. At primary receiving stations in the satellite tracking network, these tiny ferrite devices help to improve receiver performance by stabilizing the gain of parametric amplifiers from changes in antenna impedance.

Motorola Type LI01 UHF Isolator, illustrated, provides more than 10 db isolation with less than 1 db insertion loss over a 30 mc bandwidth.

Originally designed for this satellite tracking application, Type LI01 is now a standard item ideally suited for all wide band, low power applications where minimum size and weight are essential without sacrifice to performance.

REPRESENTATIVE MOTOROLA SOLID STATE DEVICES

ISOLATORS • CIRCULATORS • PARAMETRIC AMPLIFIERS • SWITCHING CIRCULATORS • HIGH-SPEED, BROAD-BAND SWITCHES • PHASE SHIFTERS •

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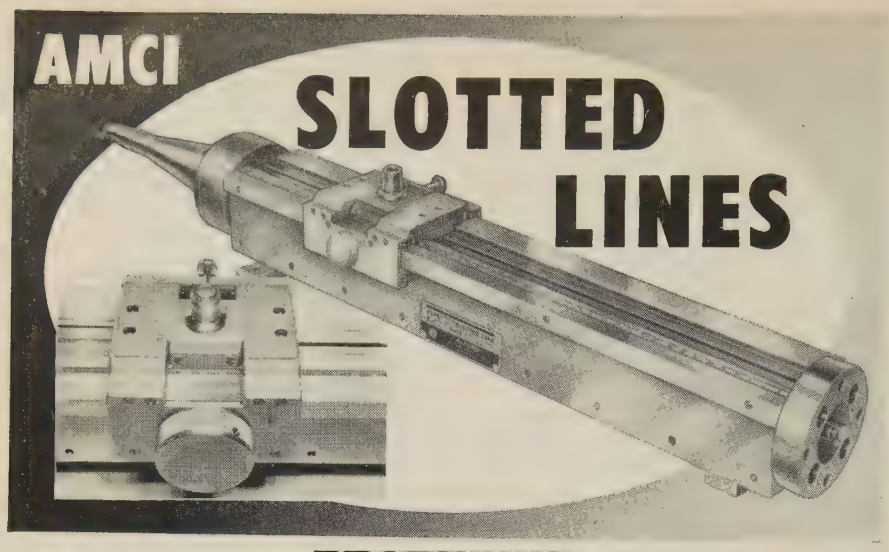
AMCI

SLOTTED LINES



FEATURES

- ***Rated residual SWR*** — under 1.010; rated error in detected signal — under 1.005.
- ***Several models*** covering various bands from 50 to 4000 mc.
- ***Engraved scales and verniers*** permit one to read the probe position to 0.01 centimeters.
- ***Optional accessory:*** a rack and pinion carriage drive than can be engaged or disengaged at will.
- ***Precision tapered reducers*** are available for use in making accurate measurements in a wide range of rigid and flexible coaxial transmission lines.

Write for complete information on AMCI Slotted Lines.

ANTENNA SYSTEMS — COMPONENTS — AIR NAVIGATION AIDS — INSTRUMENTS

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A STEP BEYOND

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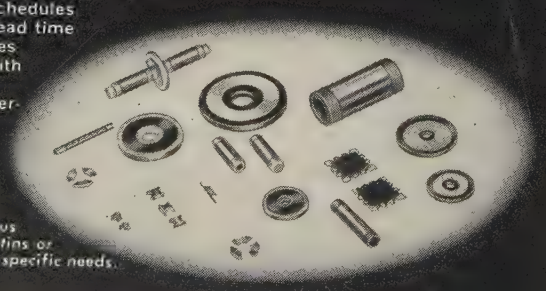

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FILM RESISTORS · INC

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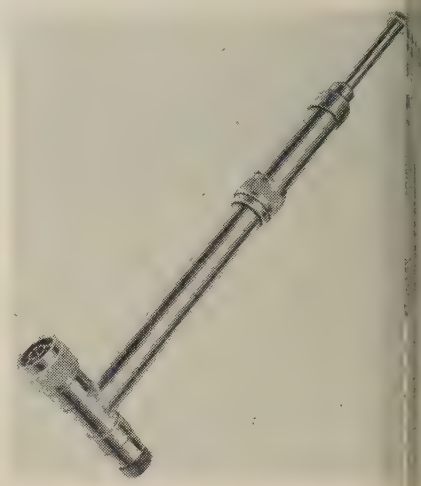
Circle Reader Service Card 50

New Products

(*Continued from page 75*)

A NEW CONCEPT IN COAXIAL TUNERS



An entirely new coaxial tuner h just been announced by Microlab, Li ingston, N.J. This tuner, known as stub stretcher, performs the functions a double stub tuner with none of i limitations.

The stub stretcher combines in single unit an adjustable shorted stu and a line stretcher. This combinatio permits the stub position to be contin ously varied with respect to the loa and thus, any load impedance can b matched to the line. The unit features novel design with both the shorted stu and the line stretcher mounted within single branch arm.

The conventional stub tuner require at least two stubs, each of which mus be at least one-half wavelength lon The stub tuner can match only a limite range of impedances and, at certain fre quencies, is extremely difficult to us because of poor convergence and critica stub adjustments. The new stub stretche has none of these limitations. It has on stub, whose length is only one-quarte wavelength. The line stretcher is in cluded within this same stub. All imped ances can be matched quickly and wit excellent convergence.

The Microlab stub stretchers are sup plied in two models, one for use fron 300 to 10,000 mc and the other fron 1000 to 10,000 mc. They are availabl with Type N, BNC, TNC, C, or HN connectors and have a power rating o 100 watts. The units are priced fro $120 to $160 depending upon frequenc range and connectors, and are availabl for immediate delivery from stock.

A detailed description of these tuners including an analysis of their operation i available.

Circle Reader Service Card 119

— *mwj* —

TWO NEW CIRCULATORS FROM MELABS

Melabs, Palo Alto, Calif., announces development of two new ferrite circulators: 400 mc Circulator Model X-127 L-Band Coaxial Circulator Model X-101A.

The Model X-127 ferrite circulator is a compact three port device which is 6½ inches in diameter, including type N female connectors, and weighs approximately 1½ pounds. The isolation is at least 20 db from 380 to 420 mc, and over the same bandwidth the insertion loss is less than 1 db.

The circulator can be provided with an electromagnet for applications requiring a switchable unit and can also be designed for use at frequencies up to 1000 mc.

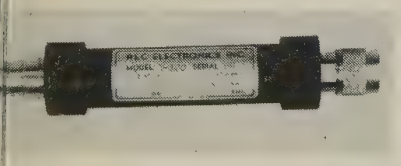
The Model X-101A broadband three port circulator is a lightweight compact unit which gives high ratios of isolation to insertion loss over better than 2 per cent bandwidths in the 1 to 2 kmc region. A circulator designed to operate at 1400 mc has better than 15 db isolation from 1200 to 1500 mc with peak isolation in excess of 20 db. The insertion loss is less than 1 db over this entire bandwidth; at band center it is typically 0.5 to 0.6 db.

The circulator can be provided with an electromagnet for applications requiring a switchable unit.

Circle Reader Service Card 120

— *m w j* —

NEW 10 WATT ATTENUATOR



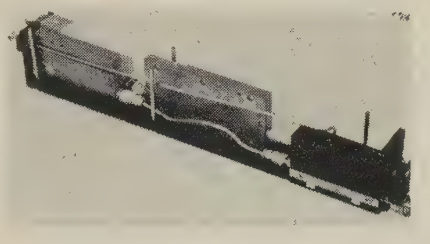
A new coaxial power attenuator designed for operation from dc to 4 kmc has just been announced by R L C Electronics, Inc., Mamaroneck, N.Y. This fixed attenuator pad, Model A 101, can be supplied in attenuation values from 0 db to 60 db. The attenuator accuracy of pads up to 30 db (including accuracy and variation of attenuator as a function of frequency), is ½ db; the accuracy of pads from 30 db to 60 db is ¾ db. VSWR of these units with Type N connectors is 1.3 maximum from dc to 4 kmc. These units are calibrated at 1.2 kmc and 2.8 kmc, and can be supplied with Type N, TNC, C, BNC connectors. These R L C Electronics attenuators are designed for 50 ohms and are fabricated from silver plated brass.

Model A 101 is but one of a line of coaxial power attenuators, ranging in power ratings up to 50 watts. Special attenuators requiring close tolerances differences in frequency range, higher power levels, special connectors, different materials and finishes, etc. can also be supplied. R L C also produces a wide range of terminations and filters.

Circle Reader Service Card 121

— *m w j* —

SPECIAL MICROWAVE SUB-SYSTEM PACKAGE



Merrimac Research and Development, Inc., Irvington, N.J., has announced the development of a versatile coaxial line sub-system package, as an example of its capability in furnishing complete subsystems. This unit, designed for use in both C and X bands, provides sampling, filtering and level control.

The unit contains an octave wide directional coupler, two band-pass filters with broad pass bands and sharp skirt selectivity, and a standard Merrimac flat coaxial attenuator.

The C band package incorporates a Merrimac AE-6 IL attenuator, while the X band unit contains the AF-6 IL attenuator. Both units are continuously-variable zero initial loss attenuators with flat attenuation versus frequency characteristics over octave bands.

The package weight is only five pounds and the over-all dimensions are 17 inches by 3⅛ inches by 2¼ inches.

Circle Reader Service Card 122

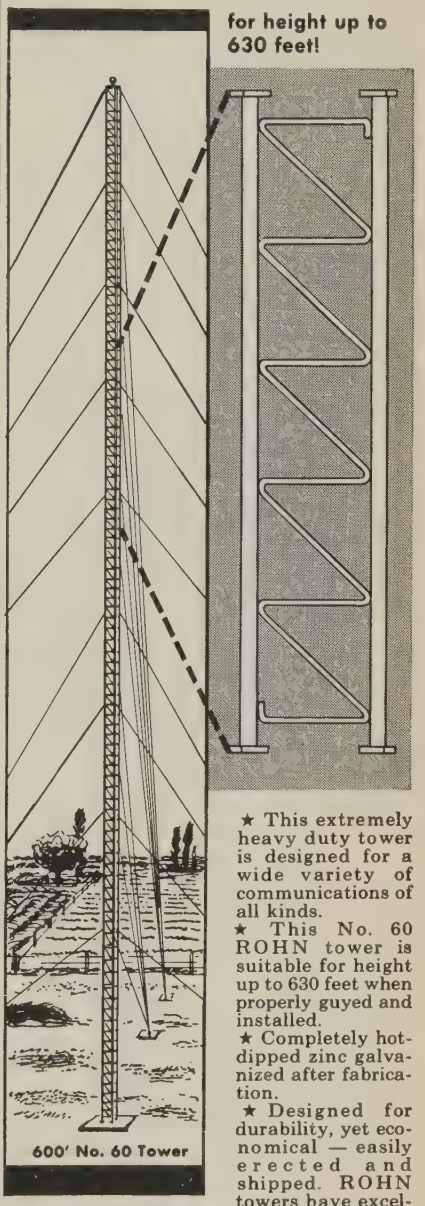
— *m w j* —

MINIATURE S BAND CONTINOUSLY VARIABLE ATTENUATOR

Antenna & Radome Research Associates, Westbury, N.Y., has introduced a miniature S-band Continuously Variable Attenuator with an insertion loss of less than 0.5 db. This unit is 3 inches in diameter

(*Continued on page 78*)

ROHN COMMUNICATION TOWER *No. 60*



★ This extremely heavy duty tower is designed for a wide variety of communications of all kinds.
★ This No. 60 ROHN tower is suitable for height up to 630 feet when properly guyed and installed.
★ Completely hot-dipped zinc galvanized after fabrication.
★ Designed for durability, yet economical — easily erected and shipped. ROHN towers have excellent workmanship, construction and design. Each section is 10 feet in length.

FREE

Details and complete engineering specifications gladly sent on request. Also ROHN representatives are coast-to-coast to assist you.

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ROHN *Manufacturing Co.*

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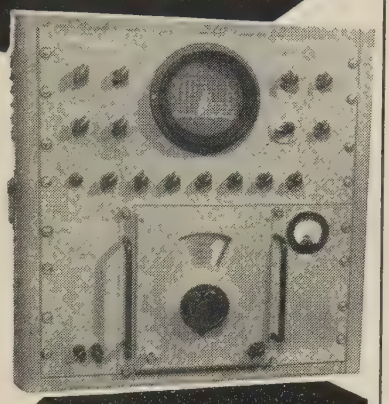
Phone 7-8416

"Pioneer Manufacturers of Towers of All Kinds"

Circle Reader Service Card 51

50 mc to 4000 mc

WITH TWO TUNING HEADS



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WITH TWO TUNING HEADS

Check these outstanding features:

- Low noise input, less than 0.5 micro volts across 50 ohms, for high usable sensitivity
- 10 mc maximum sweepwidth, continuously reducible to 0 mc
- Continuously variable differential markers, ±50 kc to ±5 mc
- Continuously variable resolution (I.F. bandwidth 9 kc to 100 kc)
- 1 cps to 60 cps sweep rate, continuously variable with single control
- DC coupled video amplifier for analysis of CW signals
- Three selectable amplitude scales 40 db log, 20 db linear and square law
- Low frequency swept oscillator provides high inherent stability
- Excellent construction and design make the equipment unparalleled for minimum down time
- Optional scale lighting, flat faced CRT and camera bezel for standard scope camera use
- Low cost

Tuning Heads: RF-2 50 mc-250 mc, RF-3 220 mc-4000 mc in five ranges

Inquiries invited on Panoramic Spectrum Analyzers for special problems. Write today for descriptive literature.

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Circle Reader Service Card 52

New Products

(*Continued from page 77*)

by 1⅛ inches high and weighs about 14 ounces. Designed primarily for airborne applications, this unit features a simple locking device and a dial plate calibrated in degrees for easy resettability. Design is of the Pi Line Vamp type with full attenuation achieved in less than 180 degrees of revolution. VSWR for bandwidths of 15 percent or less is 1.3 maximum on the input end. Total attenuation available is 20 db minimum at about 3 kmc. Connectors are type N male. Average power capacity is 10 watts. Peak power is 5 kw.

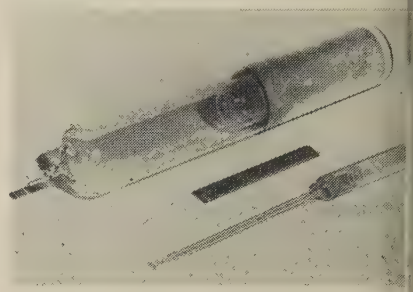
Prices are a function of customers exact electrical requirements. Delivery is about four weeks.

Circle Reader Service Card 123

— *mwj* —

NEW TR TUBES IN LOW-LOSS GLASSES AND QUARTZ FOR HIG POWER APPLICATIONS

Tucor, Inc., South Norwalk,, Con has announced the availability of a ne series of TR tubes of the folded cyli drical type for high level, high avera power applications. The tubes, des



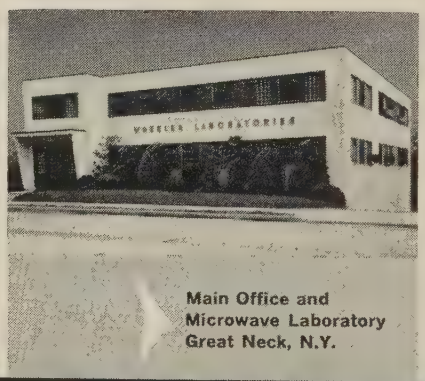
nated the T48U series, are available in wide variety of sizes and in 7052, 70 Pyrex or quartz.

Having been successfully tested in a cooled duplexers at over 100 kw ave age power, the tubes are designed cover a range from UHF to S-band.

Delivery of the T48U series is sto to 30 days depending on type.

Circle Reader Service Card 124

— *mwj* —



Main Office and Microwave Laboratory Great Neck, N.Y.

In the field of microwave engineering, Wheeler Laboratories occupies a unique position as an industrial laboratory devoted exclusively to consulting and development.

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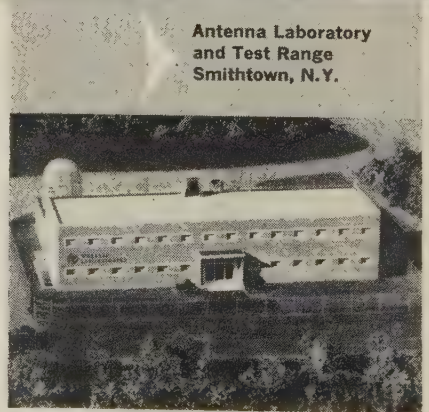


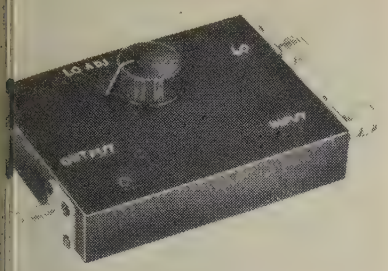
Antenna Laboratory and Test Range Smithtown, N.Y.

As a service to many prominent laboratories and manufacturers, WL designs radar and communication antennas, waveguide components, and microwave assemblies. Your inquiries are invited.

Harold A. Wheeler and Engineering Staff

Circle Reader Service Card 53

NEW BROADBAND COAX MIXER FROM PREMIER INSTRUMENT CORP.



Premier Instrument Corporation, Port Chester, N.Y., announces it is engaged in the full production of a printed circuit broad band coaxial mixer which uses interchangeable printed circuit-type diode. The P C-Mix is a compact, low noise figure mixer with local oscillator level adjustment. Designed to withstand severe vibration and shock, the P C-Mix is available in five basic units covering the frequency range 250 mc to 8000 mc.

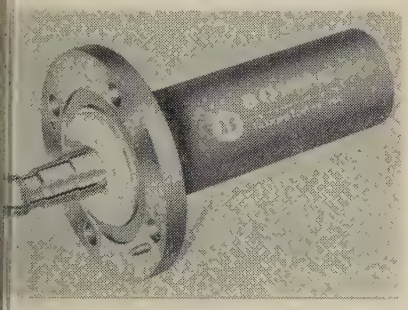
Specifications are as follows: signal VSWR — 2:1 maximum; L. O. VSWR — 2:1 maximum, and noise figure — less than 9 db.

The new mixers can be used for single or balanced mixing. Descriptive literature is available.

Circle Reader Service Card 125

— *mwj* —

BOMAC INTRODUCES NEW EXPENDABLE MICROWAVE COMPONENT



Developed by Bomac Laboratories, Inc., Beverly, Mass. for use with balanced diplexers in radar systems, this coaxial unit in 1⅝ inches 50 ohms EIA line, can dissipate an average power of 20 watts and 20 kw peak.

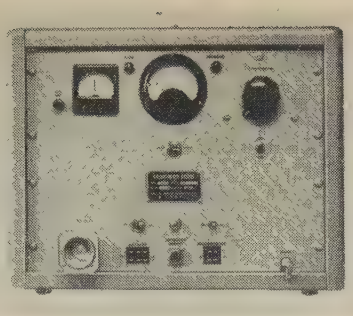
Over a range of 400 to 450 mc, it presents maximum VSWR of 1.2. Designed as an expendable component, it is being sold at a relatively low price.

Circle Reader Service Card 126

— *mwj* —

NEW CALORIMETER BRIDGES BY ELECTRO IMPULSE LAB.

A new series of high power Calorimeter Bridges for use from 10 watts to 500 watts full scale with 2 per cent or



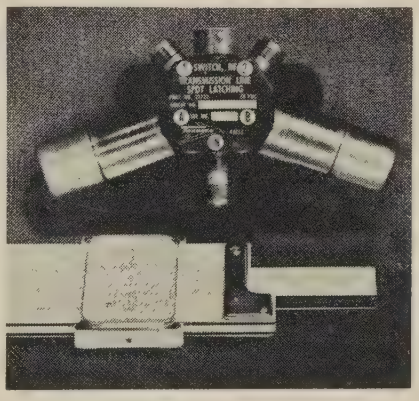
better accuracy, for the frequency range dc to 12 kmc and with coaxial or waveguide inputs is announced by Electro Impulse Laboratory, Red Bank, N.J. Designed for continuous operation at full scale power, these bridges are direct reading on all scales. They require no thermometers or flow meters and are self-compensating for wide changes in ambient temperature. Provisions are made for external galvanometer and wattmeter. Completely self-contained with RF load, these instruments measure only 22 inches x 17 inches x 18 inches.

Literature and prices are available from the manufacturer.

Circle Reader Service Card 127

— *mwj* —

NEW-DESIGN COAXIAL LATCHING SWITCH



Transco Products, Inc., Los Angeles, Calif., announces the availability of a solenoid-actuated Coaxial Latching Switch which requires no holding power.

Newly designed solenoids with a switching time of 10 milliseconds operate from 28 VDC and draw only 3.2 micro amp/hr. The new units weigh 8.7 ounces.

Typical specifications are as follows: characteristic impedance — 50 ohms; operational mode—Make - before - break; VSWR — 1.4 at 7 kmc; insertion loss — 0.4 db at 7 kmc, and crosstalk — 30 db at 7 kmc. The frequency range extends to 11 kmc.

Presently available with type N and TNC connectors, other connector types can be supplied.

Circle Reader Service Card 128

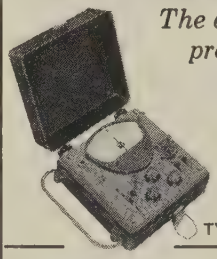
— *mwj* —

Q. Isn't there a HANDY way to test Crystals?

A. Yes...

Fast, Accurate, and ECONOMICAL too

The answer to your problem is one of these:



Video Crystal Test Set

TYPE 393 — $299.00

Microwave Biased/Unbiased Crystal Test Set

TYPE 391 — $135.00

Microwave Crystal Test Set

TYPE 390-A-3 — $97.00

You can test crystals in the field, the lab or on the line for . . .

- Relative Noise Figure
- Pair Matching
- Conversion Loss
- Relative Sensitivity
- Tangential Sensitivity

Write for descriptive literature.

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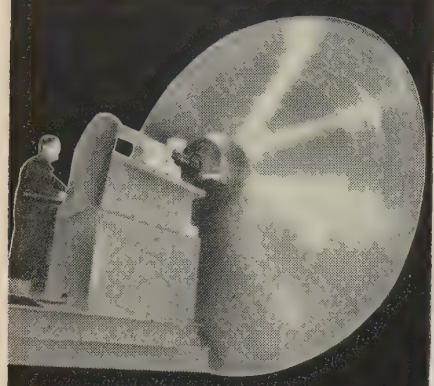


permanent tooling available . . .

C.W. Torngren Co., Inc., the largest manufacturer of spun aluminum parabolic reflector antennas in the country and originator of the exclusive Mecatorn® process, has machined and stocked permanent tooling for every diameter and focal length in popular use today. Reflectors can be Mecatorn® Powerspun from four inches to 12 feet in diameter.

No tooling charge is made for any standard Torngren reflector which is spun from 2S0 aluminum with rolled bead or straight flange. Backing and mounting structures can be furnished to your specifications at additional cost.

Since Torngren warehouses a full supply of aluminum circles, delivery is usually ONE WEEK F.O.B. Somerville, Mass., there is of course no charge for crating.

Send for our latest price list and check the savings when you spin with Mecatorn®.

C. W. TORNGREN CO., Inc.
236 PEARL STREET
SOMERVILLE 45, MASS.

Industry News

(*Continued from page 79*)

PRE-PLANNED SESSIONS TO HIGHLIGHT WESCON

A technical program that will contain pre-planned technical sessions on as many as 10 special subjects, including a whole series of meetings on "Man-Machine Systems," was outlined by Richard G. Leitner, chairman of the program.

At the same time, Chairman Arthur N. Curtiss, RCA-Los Angeles, announced a schedule of seven field trips to sites of outstanding technical interest during the four day Western Electronic Show and Convention to be held at Los Angeles, Calif., August 23-26.

Leitner, whose committee reviewed hundreds of technical papers in making their selections for the technical convention, said that these will be augmented by several sessions for which selected authors were invited to participate. Included in the group are such subjects as "Stereo-multiplexing Methods," "Information Theory and Modulation Methods" and sessions on the subject of miniaturization, air traffic control, space science and bio-instrumentation systems.

Format for these sessions will vary, including debates, colloquia and more formal programs, Leitner said. He said that a number of sessions on man-machine systems, each independent of the others, will be held over a period of two or three days of WESCON.

For the first time, a women's session will be included, Leitner said, intended to examine some of the factors affecting the technical man "away from the job." The wife's role in understanding her engineer-husband's work better is one of several sub-topics to be presented by a panel of feminine speakers.

—*mwj*—

REPUBLIC NAMES CHIEF OF NEW ELECTRONICS LAB

Appointment of Dr. Hanns S. Wolff as chief of the new Electronics Laboratory at Republic Aviation Corporation has been announced by the company.

The new facility and staff which Dr. Wolff heads is one of seven advanced research laboratories to be incorporated in Republic's new $14 million Research and Development Center, Farmingdale, L.I.

Dr. Wolff has been active in the electronics field, both here and abroad, for 32 years. He comes to Republic from the W. L. Maxon Corporation where he had been a member of the engineering staff since 1956. Prior to this assignment he was vice president and chief engineer of Leetronics, Inc. and earlier was chief engineer at General Fuse, Inc.

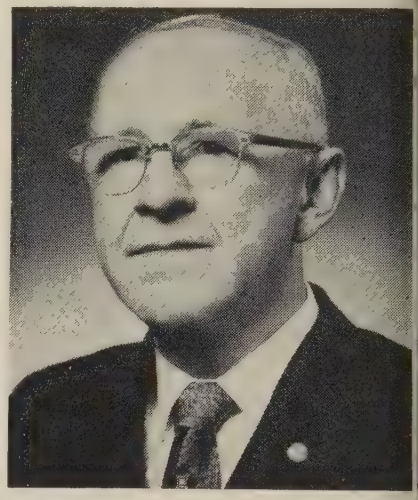
He is a graduate of the Technical University of Berlin, where he also served for two years as a professor in theory of electricity. He has held executive engineering posts with prominent industrial firms in Germany and also w a registered patents and consulting e gineer in that country.

Dr. Wolff is responsible for a numb of significant electronic developmen both military and commercial. He h been awarded more than 125 paten Some of his most recent design and d velopment work has been in the fields missile guidance and instrumentation a solenoids and relays.

At Republic Dr. Wolff directs resear studies into problems associated with ve tical take-off (VTOL) blind landing sy tems, interspace communication syste and advanced instrumentation techniqu

—*mwj*—

TELECHROME APPOINTS DEFENS PRODUCTS MANAGER



Walter A. Kirsch has joined Tele chrome Manufacturing Corporatio Amityville, N.Y., as defense product manager and assistant to the vice pres ident and director of sales, H. Charle Riker.

Telechrome designs and produces in dustrial automation systems, aero-spac electronics components and televisio broadcasting and testing equipment. Th company recently acquired Hammarlun Manufacturing Co., producer of hig quality radio receivers and transmitters

Mr. Kirsch is a senior member of th IRE. He is a member of the Arme Forces Communications and Electronic Association and is a director of the Nev York Chapter.

A sales engineer for the Servo Cor poration of America for the past year Mr. Kirsch previously was associate with Fairchild Camera and Instrumen Company for three years as superintend ent of electrical assembly and manufac ture on the Sage project.

Earlier, Mr. Kirsch spent a numbe of years in Research and Developmen with Bell Telephone Laboratories, Inc. Sylvania Electric Products, Inc. and othe companies. He also served as plant man ager for the Electronics and Instrumen Co. and the New York Division of Al lied Control Company.

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H. A. SMITH NAMED BY EMERSON & CUMING, INC.

erson & Cuming, Inc., Canton, ., has announced the appointment Howard A. Smith as national sales ger. Mr. Smith joined the firm in as New England district sales man- In his new position he is respon- for all sales efforts for the com- including its international repre- tive coverage, regional sales offices, promotion and advertising.

e two years previous to joining rson & Cuming, he was partner/ r of the electronics manufacturers' sentative organization of Smith & Associates covering the New Eng- Territory and specializing in micro- test equipment, components and rials, including Emerson & Cuming, as a principal.

ior to that, Mr. Smith's experience primarily in the microwave instru- tation field including antenna design special test equipment design, having associated with Gabriel Electronics four years along this line.

e is an active member in the IRE at present is the editor of "The ector" magazine published by the on Section of the IRE.

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NDIX APPOINTS C. E. HEITMAN TO EXECUTIVE STAFF

harles E. Heitman, Jr., former pres- t of the Carter Carburetor division ACF Industries, Inc., has joined the of George E. Stoll, executive vice ident of the Bendix Corporation, th Bend, Ind.

eitman will be responsible for major nufacturing and organizational func- s in the divisional and interdivisional s. Bendix now has 25 divisions and subsidiary and affiliated companies.

eitman held various engineering ts with Pullman-Standard Car Manu- uring Co. and the Budd Co. He ed the A.O. Smith Corporation in 0 and was a member of its marketing rd, president's staff, manufacturing mittee, inventory committee and er planning groups.

rom 1946 to 1953 he was manager of the automotive division and from 1953 to 1956 he was assistant general manager of the A.O. Smith Corporation. He was named president of the Carter division of ACF in 1956.

He received a BS degree in electrical engineering from, Georgia Tech and a MS degree in electrical engineering from Yale.

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SCOTT JOINS ENGINEERING STAFF OF LITTON INDUSTRIES

Frederick I. Scott Jr. has joined the engineering staff of the Litton Industries' Electron Tube Division, San Carlos, Calif., as a senior engineer in the Magnetron Product Line.

Mr. Scott has a broad background in super-clean techniques as well as materials and processing of high-vacuum tubes. Prior to joining the Litton Industries staff, Mr. Scott was employed by Eitel-McCullough, San Carlos, and for eight years was a design and development engineer for Radio Corporation of America, Harrison, N.J.

In his initial assignment, Mr. Scott will be working in the Miniature Magnetron Department.

Mr. Scott is a 1950 chemical engineering graduate of Johns Hopkins University in Baltimore, Md. He received his MS degree in management engineering from Newark College of Engineering, Newark, N.J., in 1956.

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NAVY CONTRACT TO G.E.

A $14 million dollar contract for the production of new long-range height-finding radar units for the U. S. Navy has been awarded to the General Electric Company's Heavy Military Electronics Department, Syracuse, N.Y., according to an announcement by J. J. Farrell, department general manager.

Designated the AN/SPS-30, this lightweight unit will be one of the longest range radars in production for the Navy and will feature a three dimensional capability which simultaneously detects the range, azimuth and height of a target, Farrell explained.

"The increase in aircraft speeds and the introduction of missiles in recent years has made it imperative for the Navy to have this new type of long-range height finding radar capable of detecting objects at extremely long ranges," Farrell said.

The AN/SPS-30 will incorporate many advanced signal processing methods and circuitry.

Work on the AN/SPS-30 is being done by the Marine and Ordnance Engineering Unit of the Company's Heavy Military Electronics Department.

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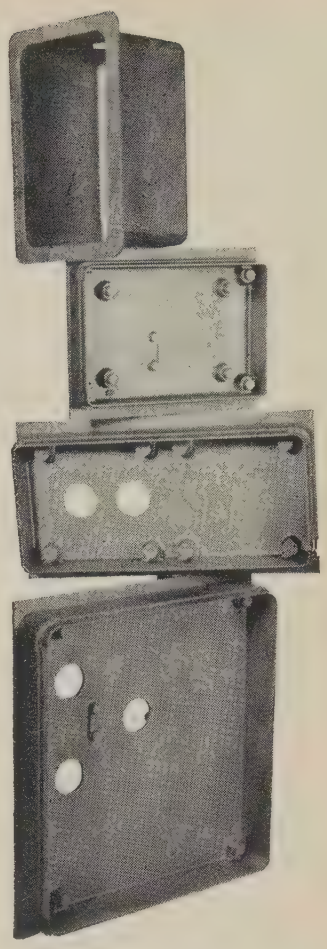
(*Continued on page 82*)



Aluminum cans for electronic applications are cast accurate, smooth and pressure tight by the unusual foundry methods of Morris Bean & Company, Yellow Springs 21, Ohio.

BEAN

aluminum
magnesium
ductile iron
foundries

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more
power
to you...

Central
XD-2

Central's 7132/XD-2* hard tube diode was especially designed for rectifier, charging and shunt diode service. As a rectifier the XD-2 will withstand 40 Kv (P.I.V.) at a 3 ampere average—150 amperes (peak) as a clipper. This tried and proven tube features a special Thoria-tungsten filament capable of high peak currents and long life, and has a very efficient external anode which can dissipate 5 Kw continuously.

** air cooled version—7131/XD-2*

If power is your problem—see Central first!

NUCOR
NUCLEAR CORPORATION OF AMERICA

Central
ELECTRONIC MANUFACTURERS
A Division of Nuclear Corporation of America
DENVILLE, NEW JERSEY
Export Department: 333 East 46th St., New York 17, N. Y.

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(*Continued from page 81*)

DAVIS, GE VICE PRESIDENT, ELECTED PRESIDENT OF ELECTRONIC INDUSTRIES ASSOCIATION

L. Berkeley Davis, vice president of the General Electric Company and general manager of the Electronic Components Division, has been elected president of the Electronic Industries Association, Washington, D.C.

Mr. Davis succeeds David R. Hull, a vice president of Raytheon Company, Waltham, Mass. Mr. Hull was first elected to the EIA presidency in 1958 and served two terms.

The EIA president-elect will head the only national trade association representing all major manufacturing segments of the electronics industry. He is the 28th president of the 36 year old association.

Mr. Davis has been a member of EIA's board of directors, a director of the association's tube and semiconductor division and a member of the membership and scope committee.

NEW LITERATURE

2KMC MICROWAVE SYSTEM LITERATURE AVAILABLE

Adler Electronics, Inc., New Rochelle, N.Y., announces the new RT-3A Heterodyne Repeater, designed for reliable, unattended TV and communications relaying in the 2kmc frequency range. It features 10 watts output power, no demodulation, use of only 29 tubes, built-in metering and monitoring, crystal-controlled frequency stability, use of 6mc channel, color or monochrome transmission, and use with standard multiplexing systems. Descriptive literature, including full technical specifications is available.

Circle Reader Service Card 129

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NEW ULTRA CLEAN FACILITY BROCHURE AVAILABLE

A new three color, eight page brochure entitled "Requirements for an Ultra Clean Facility" has been made available by Shielding, Inc., Riverton, N.J. The brochure has index tabs for quick reference. The main subject headings are: Construction and Environmental Control Systems. Sub-division discusses: Modular Wall Panels, Non-Dusting Materials, Illumination, Floor Covers, Air-Showers, Pass Through Chambers, Pressurized Cabinets, Temperature-Humidity, Air Pressure, Air Replacement, Filtration, etc.

A perforated application information form is attached which enables each potential user to get engineering information for Shielding on his particular application.

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ITTON OFFERS BOOKLET ON ITS PRODUCTS AND FACILITIES

Facilities and products of the 13 divisions comprising tton Industries are described in a 40 page illustrated oklet.

The corporation is made up of four operating groups — ilitary Equipment and Systems, Business Machines, mponents, and Communications Equipment and Sysms. Photos and drawings in two colors help define the tton complex.

Circle Reader Service Card 131

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MANUAL ON MICROWAVE MEASUREMENTS AVAILABLE FROM NARDA

An 85 page booklet "Microwave Measurements Manl," designed to aid persons new to the field of microave measurements is available from The Narda Microave Corporation, Mineola, N.Y., at $2.00 per copy.

The Manual is divided into two sections. The first is Theory and Application" and describes microwave cirits and devices; the second is "Laboratory Experiments" d is concerned with microwave measurements as enountered in typical laboratory work. The manual is well ustrated with pictures of equipment, test setups and pical data plots.

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(*Continued on page 84*)

IF YOU DEPEND ON FERRITES ...YOU DEPEND ON IRVAN

from microwave to recording head frequencies, Irvan has a national reputation for superior performance. Irvan has the most omplete and up-to-date facilities in the country for ultrasonic, surface, centerless, OD and ID grinding and has on hand over 30 grades of ferrite material for "yesterday" delivery on your ferrite orders.

IRVAN ENGINEERING
13856 Saticoy Street Van Nuys, California STate 1-2620

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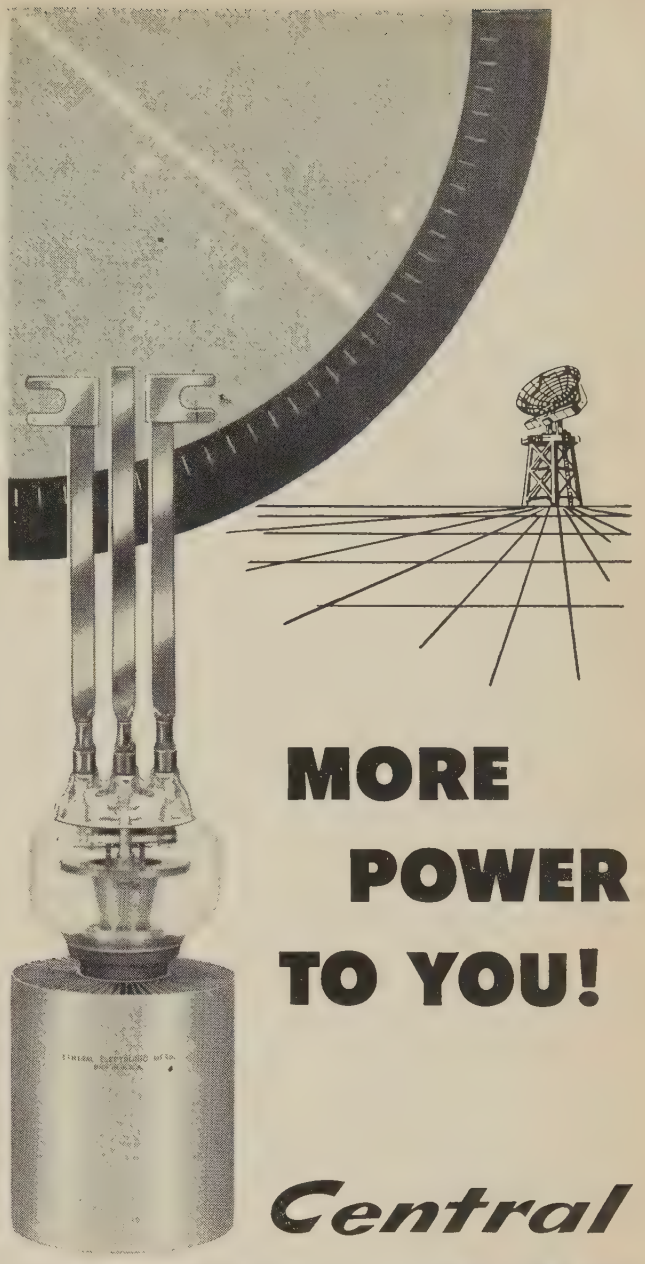

MORE POWER TO YOU!

Central XD-45

Today's radars demand more pulse power in less space. Central's answer is the 7545/XD-45, specifically designed for switch tube service. Though compact in size, this proprietary tube will switch 3.4 megawatts at 25 Kv hold-off anode voltage with pulses up to 25 u seconds, 200 amperes peak. The XD-45 is air cooled— 6 Kw anode dissipation, and is available from stock.

When your design calls for pulse power— see Central first!

NUCOR
NUCLEAR CORPORATION OF AMERICA

Central ELECTRONIC MANUFACTURERS
A Division of Nuclear Corporation of America
DENVILLE, NEW JERSEY
Export Department: 333 East 46th St., New York 17, N. Y.

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NEW hard, rugged, rigid, tough Corning FOTOCERAM* attenuator plates

There are times when you need attenuator plates that will take some jarring and jouncing. There are times when you need a plate that shakes off water like a duck. There are times when you want a plate that still attenuates when the temperature zips up high. When such times arrive, consider the properties of Corning FOTOCERAM glass-ceramic plates:

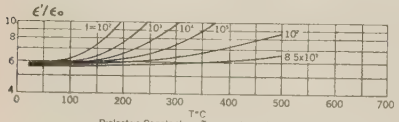
Flexural strength, psi 25,000
Thermal expansion, °C ..... 104 x 10^{-7}
Strain point, °C 700
Volume resistivity ohm/cm 25°C ..... 6 x 10^{15}
Power factor 1 mc 20°C ..... .006
200°C ..... .14
Dielectric constant 1 mc 20°C 5.6
200°C 6.3
Loss factor ..... .034
Dissipation factor 1 mc 20°C ..... .0062
Water absorption is zero. FOTOCERAM is also impervious to oils and organic solvents.
Temperature range. Will operate continuously at 250°C. without sag or warp.

We'll build the plates *to your specs.* Both chrome and nichrome films. Resistivities from 20 to 200 ohms per square.

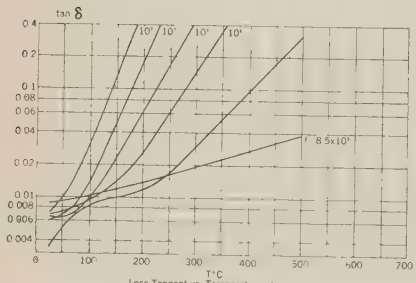
Rectangles or parallelograms with squared or tapered ends. Thicknesses from 0.027" to 0.125". Tolerances on holes run ±0.003" to ±0.005", on hole spacing ±0.005".

We'll send you complete data, if you will send your name and address to the Corning Glass Works, 552 High Street, Bradford, Pennsylvania.

* Trademark



Dielectric Constant vs Temperature at various frequencies between 100 cps & 8.5 kilo-megacycles



Loss Tangent vs. Temperature at various frequencies between 100 cps & 8.5 kilo-megacycles

CORNING ELECTRONIC COMPONENTS

CORNING GLASS WORKS, BRADFORD, PA.
Circle Reader Service Card 60

New Literature

(*Continued from page 83*)

HIGH ALUMINA TECHNICAL CERAMICS BROCHURE

Diamonite Products Manufacturing Company, Shreve, Ohio, has available a new brochure covering data and the application of high alumina technical ceramics to the electronics industry.

"Off the Shelf" service for standard rods, tubes and cylinders are listed with prices in various quantities. The six page brochure contains a chart of comparative properties of Diamonite materials for electronic applications. It covers all factors — physical, electrical and environmental — of the material so that potential applications can be evaluated. A graph of dielectric loss factors of Diamonite material on a comparative scale is also shown.

Diamonite, the trade name of the high alumina ceramic materials used, contains up to 97 per cent aluminum oxide and is frequently referred to as a synthetic sapphire substance. It develops extremely high strengths at elevated temperatures and is capable of withstanding repeated heating to over 1000°C with air quenching without loss of strength.

Parts and components of Diamonite materials are non-magnetic, non-conductors of electricity and possess high dielectric strength at high frequencies and elevated temperatures. The material is vacuum tight and readily metallized.

A complete resume of the various facilities available through the company are also listed in the brochure. These include original analysis as to application, engineering service, prototype models and production runs to meet delivery requirements. Miniaturized as well as regular sizes of parts and components can be had in production quantities.

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NEW CATALOG OFF PRESS

LEL, Inc., Copiague, N.Y., offers its new Catalog No. 60 providing 32 pages of information on microwave receiver front ends including data on a number of waveguide, and coaxial mixer-preamplifier assemblies. Other products described include solid-state, miniature and sub-miniature IF amplifiers, TWT amplifiers, octave RF amplifiers, beacons and AFC units.

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AMERICAN TUBE BENDING CATALOG

The Electronics Division of the American Tube Bending Co., New Haven, Conn. is offering a new four page, two color, fully illustrated catalog on configurations of Phelps Dodge aluminum sheathed air dielectric coaxial cable. The new processes developed by the American Tube Company, based on 50 years of bending experience, allows the use of highly complicated shapes and configurations of Styroflex, Spirafil and Foamflex coaxial cable ranging in size from ⅜ inch to 3⅛ inch diameter without mechanical or electrical disturbance.

Until these methods were developed by American Tube, no dependable and versatile method existed for bending the cable. In many instances, the cable was used only in long, uninterrupted lengths. At connection points, braided cable, fittings and special transition devices were necessary. These procedures increased costs and electrical losses and severely limited use of the Phelps Dodge cables. Now the cables' utilization in spacecraft, radar, electronics and general communication industries is immeasurably widened.

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KINGS ELECTRONICS ISSUES NEW TNC CONNECTOR CATALOG

Complete technical data on the TNC Series of Coaxial Connectors manufactured by Kings Electronics Co., Inc., Tuckahoe, N.Y., are contained in their new 12 page catalog.

Featured in this two color bulletin is a TNC Functional Diagram which graphically illustrates the types and flow of connectors by various cable sizes. Also included is a comprehensive presentation on Calibrated Reliability with accompanying graphs.

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(*Continued on page 89*)

RANTEC CORPORATION

CALABASAS • CALIFORNIA

Rantec's new manufacturing facility.

Although it requires many ingredients to build a successful company, creative engineering ability has probably been the main factor which, within four short years, has established Rantec Corporation as a leading company in the rapidly expanding microwave industry.

When founding Rantec, Robert Krausz, who has been president since its incorporation, recognized the need within the industry for a flexible company which combined a creative environment and an effective manufacturing facility. Krausz said, "At that time (the summer of 1955), there was a definite lack of fast-moving, medium-sized companies which could assume complete responsibility for the difficult microwave component jobs from research and development through manufacturing and delivery." To create such a company, Rantec started with a nucleus of engineering personnel with outstanding capabilities and experience. Substantial stock ownership on the part of key employees was a key factor in maintaining staff stability and attracting new senior personnel. This stock participation plan, careful staff selection, and the availability of challenging work in a creative environment have been so successful that Rantec has not lost an engineer in 4-½ years.

Rantec opened its doors in 1956, and its product line now covers a broad segment of the microwave and radio frequency spectrum, including antennas, telemetry multiplexers, ferrite devices, waveguide components, special test equipment and r-f subsystems. The company now occupies 35,000 sq. ft. at Calabasas, California, and its employees number approximately 100. The company's output for the fiscal year ending August 1960 will be over 1.5 million.

Original Founders

Robert Krausz's background combines the engineering and business talents necessary for guiding Rantec to its present position. He received his electrical engineering degree at Ohio State University, where he remained as a Research Associate in the Antenna Laboratory. He entered industry as a Specialist at North American Aviation's Aerophysics Laboratory, where he gained experience in the development of missile antennas and microwave components and systems.

In 1951 he became a principal and Chief Engineer of Microwave Engineering Company, which was eventually acquired by Stanford Research Institute. Krausz remained in charge of the facility at Mount Lee in Los Angeles until the time of Rantec's formation by Krausz, Dr. Robert S. Elliott, and Alvin Clavin. Elliott, then Head of the Antenna Radar Section at Hughes Aircraft Company, was well known for his work and publications on surface wave antennas, arrays, and microwave techniques. Clavin had been engaged in pioneer work in ferrite devices. This relatively new ferrite field promised to play an increasingly important part in microwave systems.

The initial senior staff was completed with the addition of two key engineers, Louis A. Kurtz and Samuel A. Rosen. Kurtz came from Hughes Aircraft with an impressive background in antenna development including two-dimensional slot arrays, frequency scan and monopulse antenna systems. Rosen had considerable experience in microwave instrumentation at M.I.T.'s Radiation Laboratory and was Head of Radome Instrumentation at Hughes before joining Rantec.

(*Continued on page 86*)

(*Continued from page 85*)

After looking at practically every available hill from Oxnard to Pomona suitable for antenna pattern range and plant location, a site was selected in an ideal spot at Calabasas, California. With the completion of the new Ventura Freeway, Rantec is now only 30 minutes from downtown Los Angeles. After many long discussions the company name was also chosen from the words *R*adomes, *ANT*ennas, and *E*lectronic *C*omponents.

Early History

Initial work obtained by the new Company was essentially consulting in nature, augmented by antenna and radome testing programs for local airplane companies. The first major contract came from an electronics company for the development of the r-f section of a test set involving the Sparrow missile program. The system involved a number of special ferrite devices and waveguide assemblies, and has resulted in production and spare parts support business over the past few years. Other hardware contracts for antennas, feed assemblies, and ferrite devices were mostly a direct result of company sponsored research programs.

A unique two-dimensional, slot-array antenna which offers important advantages in both size and performance over the normal feed and reflector systems was developed by Mr. Kurtz. This antenna employs four ferrite phase shifting devices and is ideally suited to homing applications employing conical scanning, lobe switching, or monopulse techniques.

Mr. Clavin's background contributed to the development of much needed special ferrite components, and work was started on the design of load isolators, circulators, and phase shifters. It later became apparent that the phase shifter techniques so developed were necessary to the design of the antenna array described above. Rantec now has a complete line of ferrite phase shifters covering X and K-band. A series of load isolators and circulators were also developed, and this experience led to more complicated related devices including high speed ferrite switches. These switches have found a number of applications in antenna lobing, duplexing, and radio astronomy.

Following the initial development and general acceptance of Rantec's early ferrite devices, more sophisticated applications employing ferrite techniques were exploited. The single sideband modulator is a good example of this type of product. The unit produces frequency translation of the incoming signal by means of two ferrite balanced modulators and has found use in a number of microwave test equipment applications.

A further area of Rantec's early company sponsored research involved telemetry components such as multiplexing filters and helical antenna systems. William H. Harrison, following initial work by Kurtz, has contributed greatly to this program, and Rantec now produces multiplexers for most of the major missile and ground support programs. Just completed and now in production is a novel 3-channel multiplexer, employing nine cavities, for use on Project Mercury. Telemetry components such as filters, multiplexers, and telemetry antennas have accounted for a major portion of Rantec's sales during the past four years. The Company's position in the telemetry field is now well established, and continuing development of

Production test laboratory for multiplexers, filters and telemetry components.

View of machine shop area in manufacturing facility.

anced products to meet the ever changing technical ands of the telemetry programs is anticipated to main- Rantec's leadership.

rent Activity and Products

Even though Rantec continues to limit its activity to chosen field of specialization, the scope and dollar me of these activities is growing steadily. To support growth both fabrication and engineering capabilities e required significant additions. Over the past two rs the engineering staff has been increased to approxi- tely 25 technical people, and a modern manufacturing ility has been in operation since January 1960. This w plant includes a precision machine shop, assembly a, dip-brazing facility, plating and other necessary oper- ns for complete manufacture of microwave compon- s. A "high-bay" area is provided for assembly of large ix antennas and arrays.

tennas: During 1958 Rantec received development ntracts for telemetry antennas, including four and eight ix arrays for tracking Pioneer, Explorer, and Discoverer ies satellites. These multi-helix arrays are now in- lled at a number of tracking and missile test bases in- ding Cape Canaveral, Vandenberg, Hawaii, Singapore, l Manchester.

Rantec has also gained considerable reputation for de- ning and building feed assemblies for several large cking antennas. Notable among these is a circularly larized tracking feed designed and fabricated for Jet opulsion Laboratory's 85 ft. reflector at its Goldstone e for use on Project Echo's communication studies with orbiting satellite.

The "flat-plate" slot array antenna mentioned above, s found application in important missile homing systems . appears to be the first electronic conical scan system ccessfully employed in a missile. This antenna, due to high aperture efficiency and lack of frontal feed inter- ence, has a physical size and form factor ideally suited r-f system packaging where size and weight are at a emium. The electronic scan feature can provide higher n rates with superior modulation sensitivity than me- nically scanned systems.

Another area of activity is the design and production of radar augmentation antenna systems for drone aircraft. Several programs for target and reconnaissance drone antenna systems are presently in the development and production phases.

Ferrite Devices: The firm continues to find a ready market for its line of isolators, circulators, modulators, and other ferrite devices and is currently expanding production facilities for ferrite products. Mr. Clavin commented recently, "From an engineering standpoint the art of using ferrites and garnets in microwave devices is changing so rapidly that the future is extremely difficult to predict. However, it cannot help to be challenging, and we will try to keep ourselves technically in a strong position to play an important part in these new developments."

Telemetry Components: Items such as multiplexers, filters, hybrids, and other components for the telemetry frequency bands continue to constitute one of Rantec's major product lines. A number of new development programs, both customer and company sponsored, are now under way to augment the present line as well as to fulfill requirements for new applications.

Special Test Equipment: The Electronics Laboratory, headed by Rosen, has developed a number of equipments, utilizing both electronic and microwave circuits, for use with Rantec's microwave devices and specialized test sets. Several of these items, such as the Iso-Modulator, have been added to the product line as special test equipment. The Iso-Modulator is a self-contained unit, consisting of a ferrite isolator, ferrite modulator, and printed circuit electronics, and finds ready application to laboratory measurements by eliminating problems associated with double moding, klystron modulation, and signal spectrum.

Driver units for Rantec's ferrite switches, phase shifters, and modulators are also products of the Electronics Department.

Several programs for the development of consoles to check missile microwave systems are active. This equipment employs a number of standard company products

(*Continued on page 88*)

Rantec officers: (left to right) Earl Arnold, secretary-treasurer; George Singer, vice president, marketing and contracts; Rob Krausz, president and Seymour Cohn, vice president, engineering and research.

Rantec Profile

(*Continued from page 87*)

and utilizes the ferrite single sideband modulator in applications where more costly and shorter-life traveling-wave tubes were formerly used. The Company foresees a continuing requirement for custom design of complex test and checkout systems. Rantec's advanced component experience frequently permits unique designs of such test equipment with a short time scale.

Under contract with M.I.T. Lincoln Laboratory, Rantec has designed the test equipment for plasma studies in a hyper-velocity ballistic tunnel. This program, including the current experimental work, is under the direction of Charles Chandler, who was formerly Head of the Antenna and Microwave Department of Gilfillan Bros., Inc.

R-F Subsystems: Based on the components available and the development programs conducted for various major electronics companies, Rantec has recently been increasing efforts to obtain business in designing and building r-f subsystems. These systems involve mixers, directional couplers, ferrite devices, antennas, and other components which must be packaged to fit the requirements of the over-all microwave system. Major companies are finding that smaller concerns, such as Rantec, can supply invaluable engineering and production assistance in these areas due to their ability to redesign the basic components employed consistent with the performance and form factor required of the subsystem package. The administration of a program of this type is often simplified considerably when a single subcontractor is made responsible for the complete sub-package, rather than procuring individual microwave components and then coordinating the packaging, and system testing.

General Information

In discussing Rantec's future, George Singer, who has joined the company within the past year as Vice President, Marketing and Contracts, comments, "The present range of products coupled with the abilities and reputation of the technical staff assures Rantec an important role in the expanding microwave industry. With the new manufacturing plant, the strengthening of the management team, and the financial backing available, we are in a position to increase our backlog and sales considerably. Current negotiations have resulted in contracts for production items in the one-half million dollar category, so we now fe that we are beyond the small research company stag Singer is well known in the aircraft and electronics i dustry, having spent the seven years prior to joining Ra tec with General Precision, Inc., in sales management a as General Manager of the firm's Microwave Division.

Current Rantec output of $1.5 million annually is ge erated primarily from customers in the California ar and prior to May 1960, little or no formal sales effo has been undertaken in other parts of the country. the California area Rantec will handle marketing wi company technical sales personnel, and in the rest of t country a network of technically oriented Sales Repr sentatives is being established. To date, G. Curtis Eng and Associates represents Rantec in lower New Yor Philadelphia and New Jersey; Industrial Associated Ele tronics, Inc., in Texas, Kansas and New Mexico; Measur ment Equipment Co. in New England area, and Gram & Co. in Arizona. Additional representatives to provi national sales coverage coupled with an expansion in th marketing Department, should effect growing sales wi new groups of potential customers.

The most recent addition to Rantec's management sta as Vice President and Technical Director is Dr. Seymo Cohn, formerly Manager of the Electromagnetics Labor tory of Stanford Research Institute. Dr. Cohn is a Fello of the Institute of Radio Engineers and is well known readers of engineering publications for his many technic articles on theory and design of filters, antennas, and m crowave components. He is also an associate editor of th Microwave Journal. In 1954 Dr. Cohn received the A nual Award for Advancement of Basic and Applied Scien from the Yale Engineering Association. Under Dr. Cohn direction Rantec is contemplating an expansion of activi in microwave filters, parametric amplifiers, and other no linear devices.

Dr. Cohn is replacing Dr. R. S. Elliott, who has returne to the teaching profession as a Professor of Engineerin at the University of California at Los Angeles. Dr. Ellio will remain as a consultant to Rantec

With its present product line, facilities, sales an financial status Rantec has progressed to the stage whe the foundation is laid for future expansion. Rantec mar agement intends to promote this growth at a rate con sistent with the Company's ability to serve the microwav industry by making significant contributions on both en gineering and production programs.

w Literature

(*Continued from page 84*)

RAK ELECTRONICS COMPANY OFFERS PATENT BOOKLET

rak Electronics Co., Division of S Laboratories, Inc., Wilton, Conn., ounces availability of "Preparing for ent-hood," a booklet about patents inventors and engineers.

ince "Preparing for Patent-hood" first eared in print in 1954, there has been ontinuing demand for it from many rces. The booklet has just been re- d and reprinted. At the advice of a lisher in the electronics field, Trak tronics Co. is again making this lication available.

Preparing for Patent-hood" tells what do with your invention idea, when to with a patent attorney, importance dates and a verifier, about the patent ce, application handling, revising ms, claims and patents, economic im- rance of patents and foreign patents.

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— *mwj* —

NEW THERMISTOR MANUAL

nwal Electronics, Inc., Framingham, ss., has just released a new thermistor nual — EMC-3. This 24 page book cribes what thermistors are and what y do, gives several examples of how y are used, tells how to solve thermis- problems and contains a listing and ir ratings of Fenwal Electronics' line thermistors. It also includes resist- e-temperature tables and a list of aids t Fenwal Electronics has available to p you solve thermistor problems.

Circle Reader Service Card 138

— *mwj* —

H-V BREAKDOWN AND SULATION RESISTANCE MANUAL

A new manual describing methods and uipment for high voltage breakdown d insulation resistance tests to meet gh reliability specifications and extend- environmental conditions has just been ued by Associated Research, Inc., Chi- go, Ill.

Equipment is shown for measuring to e million megohms and for high volt- e, leakage tests at 150 kv and higher electronic components, cables, wiring rnesses, completed assemblies, as well control circuits of all types.

Circle Reader Service Card 139

— *mwj* —

NEW MICROWAVE ANTENNA CATALOG

Andrew Corporation, Chicago, Ill., manufacturer of antenna systems has issued their new 1960 Microwave Antenna Catalog. This 16 page catalog provides detailed engineering data on 60 antennas covering all current commercial and military microwave frequency ranges. Selected cables, waveguides and anti-icing devices are also offered. Andrew Catalog M is available upon request.

Circle Reader Service Card 140

— *mwj* —

FACILITIES BROCHURE

Availability of a new brochure describing the facilities and services of Systems Laboratories Division of Electronic Specialty Co., has been announced by Floyd Sherman, director of Program Development of this division, which occupies a newly-completed addition at the company's technical laboratory, Los Angeles, Calif.

The brochure contains a concise resume of some of the projects with which Systems Laboratories has been associated, as well as a short rundown on the technical staff and facilities this division has to offer.

Systems Laboratories concentrates its efforts in the preliminary design and analysis of space age weapons systems. These efforts, conducted as a prime contractor to the government as well as a subcontractor to the defense industry, have been concerned primarily with the research and development requirements for advanced military programs.

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— *mwj* —

KLYSTRON AND PLANAR TRIODE BROCHURE

The characteristics and applications of a wide range of klystron oscillators and rocket planar triodes are described in a new brochure announced by Sylvania Electric Products Inc., Buffalo, N.Y.

David H. Simon, advertising-merchandising manager of Sylvania's Special Tube Operations, said the new booklet contains operational data on the company's complete line of disc seal and metal klystrons and Sylvania rocket tubes for pulse oscillator, CW oscillator and other applications up to 3300 mc.

"Listed for the first time is information on the SK-220 and SK-222 series which operate with one watt output in the 6125 to 8100 mc range," Mr. Simon said.

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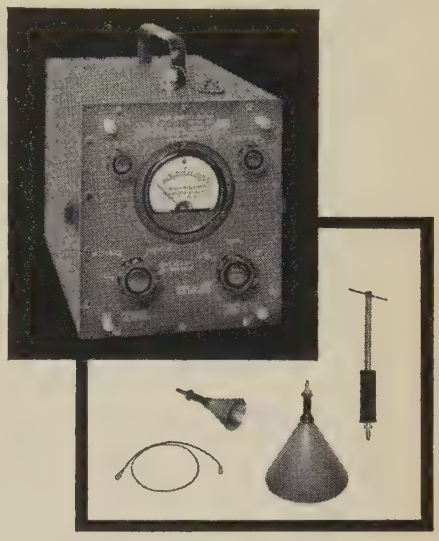
— *mwj* —

BROADBAND POWER DENSITY METER Model NF-157

For fast, accurate determination of RF power density and location of areas presenting RF hazards to personnel



Description: **A broadband device providing direct reading of RF power densities from 1 mw/cm² to 1000 mw/cm² (mid-scale readings), over the continuous frequency range from 200 to 10,000 MC.**

Features:

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- Broad frequency range and high accuracy permit universal application to mapping of high level RF fields from VHF to X-Band.
- Accurate built-in step attenuator provides capability of handling power densities over a dynamic range of 10,000 to 1.
- Three constant-gain calibrated probes permit direct reading in mw/cm² over the continuous frequency range from 200 to 10,000 MC.
- Physical separation of probes from main unit vastly increases flexibility of applications.
- Battery-powered, light-weight design permits complete portability.
- Convenient carrying case simplifies transportation of instrument.
- Efficient shielding prevents stray RF pick-up.
- Conservative design insures resistance to over-load.
- Main unit may be used independently as an accurate, rugged RF power meter over a wide power range.

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DISTORTION ANALYZERS • IMPULSE GENERATORS
COAXIAL ATTENUATORS • CRYSTAL MIXERS

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PGMTT

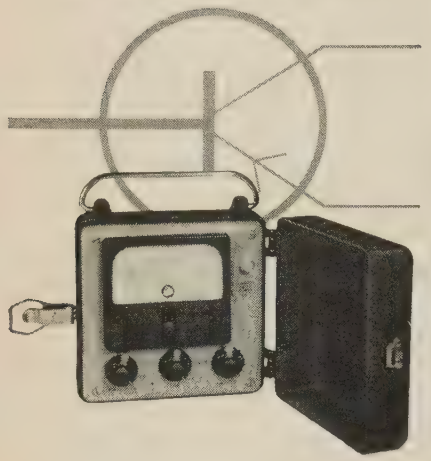
1960 National Symposium

The 1960 PGMTT Symposium at San Diego, as has been reported so ably by our Editor on page eight of this issue, marked a new departure for Symposia sites.

Those unable to attend, (especially wives), will find it hard to appreciate the austerities so patiently borne at the affair by this segment of the scientific community. The crash of the Pacific surf on the white sands, that made sleeping so difficult. The suffocating scent of flowers borne through the windows on the morning breeze. The mysterious unknown, lying so close across the International Border.

We offer this group of photographs to demonstrate how well the Professional Group sustained these hardships.

TRANSISTORIZED POWER BRIDGE



measure microwave power directly, quickly, accurately

The AIL Type 50 R-F Power Bridge applies the most advanced transistor circuitry techniques to power measurements in the 10-40,000 Mc range. Full scale ranges of 1.0 and 10 milliwatts and plus and minus 10dbm are provided. Accuracy within 0.5 db.

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Direct your ingenuity to the design of circuits forming integral parts of CW range measuring equipment and the integration of complex timing and coding circuitry for earth satellites. You will also establish and supervise test programs, direct the testing of setups, component parts, circuits and complete ranging systems, supervise and monitor electrical and environmental testing for qualification. Familiarity with transistor switching circuitry is required.

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Qualified engineers are required immediately for in-process, final acceptance and testing of electronic and electromechanical equipment associated with missile and satellite tracking systems. Types of equipment include data processing, UHF and VHF transmitters and receivers, antenna systems.

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6559

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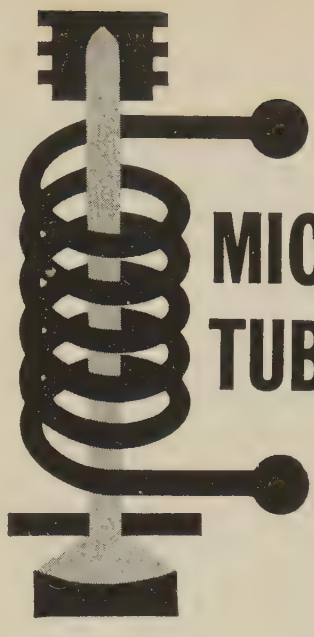

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We assist with relocation expenses. Interviews may be arranged by writing, or telephoning collect to:

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San Carlos, California
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San Carlos, California

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THE CHALLENGE: generation of system specifications, initial design, and development of all facets of radio frequency circuitry for pulse doppler radars.

BS/EE degree + graduate work in math and electrical networks; + minimum 3 years' experience in design of radio frequency "front ends" for pulse doppler radars. Specific development experience necessary in at least 2 of these: highly stable, high frequency oscillators; high power, fast recovery duplexers; master oscillator-power amplifier (MOPA) tube chains at microwave frequencies. Desirable: familiarity with high power travelling wave tubes, backward wave amplifiers and backward wave oscillators.

2. ANTENNA ENGINEER

THE CHALLENGE: leading initial antenna research and design + conceiving satisfactory theoretical solutions to radiation and scanning problems with only fragmentary information.

Advanced degree in physics or communications engineering, with emphasis on electromagnetic theory and advanced math. Also 2 years' or more experience beyond school in fundamental design and formal math analysis of microwave antennas. Major importance: design exp. with flush mounted antennas, two dimensional arrays, electronically scanned antennas, and dielectric lenses. Experience in monopulse antennas and microwave phase shifting techniques desirable.

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Letters to the Editor

Editor
the microwave journal

Dear Mr. Saad:

This letter is in reference to the article "A Set of Practic Design Data for Quarterwave Coaxial (TEM) Cavities" by Gl Bostick that appeared in the April 1960 issue of the *microwa journal.*

I would like to know what r and θ is in Illustration 3 page 79. The definition seems to have been omitted from t illustration. Thank you.

Yours truly,
Sidney Sonsky
ITT Laboratories, I

—*mwj*—

Mr. Sidney Sonsky, EE
ITT Laboratories, Inc.

Dear Mr. Sonsky:

Thank you for your interest in the Quarterwave Cavity arti (*microwave journal,* April 1960, pp. 79).

I'm sorry that the r and θ definitions were omitted thanks very much for calling attention to this.

These are:

r = radial distance from the cavity axis to the loops ge metric center

θ = electrical degrees from the shorting plane (joining inn and outer conductors) to the loop's geometric center

Please let me know if I can help further.

Most sincerely,
Glyn Bostick, Chief Engin
Radar Design Corporation

—*mwj*—

Tore N. Anderson, Esq.
New York, U.S.A.

Dear Mr. Anderson,

Thank you for your letter of the 14th March enclosing yo January article from the *Microwave Journal* on Wavegui Standardization. You will be pleased to know that we a subscribers to the Journal.

I found your article very interesting but I believe I am c rect in saying that the original English Waveguide si 1 inch x ½ inch, 3 inch x 1 inch etc. were designed spec cally for their electrical performance and I have heard ma people regret their being superseded.

As you perhaps know, we are manufacturers of Waveguic and I enclose our catalogue for your perusal. In the mat of tolerances I have followed the battle over them with mu interest and no little concern as it seems to me that toleran are becoming very loose indeed in some directions. In sp of this, however. we do find that there is a considerable d mand for our Waveguide from many overseas users includi a number of friends in the United States.

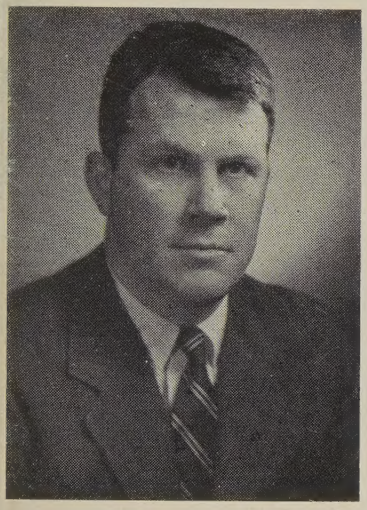
Yours sincerely,
H. J. Bailey
Evered and Co., L
Smethwick, 40
Staffs., England

—*mwj*—

THE INTERACTION OF THE MICROWAVE INDUSTRY WITH THE INVESTMENT COMMUNITY

DANA W. ATCHLEY
PRESIDENT

MICROWAVE ASSOCIATES
Burlington • Massachusetts



DANA W. ATCHLEY, JR. received his BS degree from Harvard College in 1939, studied in Cruft Laboratory at Harvard University from 1939-40, and was research engineer at Hygrade-Sylvania Corporation from 1940-41. He received a letter of commendation for his work as Lt. Com., USNR, Staff, in the Naval Research Laboratories during World War II. From 1945-47 Mr. Atchley was government sales manager in the Electronics Division of Sylvania Electric Products, Inc., was sales manager and then director of Engineering, Tracerlab, Inc. from 1947-51, and in 1951 became co-ordinator of Technical Research for United Paramount Theaters, Inc. He joined Microwave Associates, Inc. in 1952 as president.

Mr. Atchley is the author of several technical articles, the holder of several patents and is a member of the IRE. Since 1953 he has been an active radio amateur.

Timing is one of the necessary ingredients for the successful operations of any business. Two years ago the microwave industry began to emerge as a complex within the electronic spectrum. The growth pattern of this field has assumed sizeable proportions. Dollar volumes analyzed in this industry have surprised even the sophisticates in the financial world.

The recognition of an activity known as "the microwave industry" was rapid. In the intervening two years, we have noted some groups that have fallen by the wayside. Other groups have been hard put to retain their position and have had little movement in this period. We take cognizance of that group that has risen to the challenge and moved rapidly to consolidate this growth.

Wall Street has noted microwaves and their influence in "the electronics stock." Standard and Poor's recent series on the "microwave industry" gives acknowledgement to this fact.

This July issue starts our third year. On this anniversary occasion, we have asked Dana Atchley to give his views of the events that have transpired over the past two years and their effect on the microwave industry. His excellent analysis of the size of the microwave industry and its dollar volume in 1958 has been corroborated by the BDSA survey. He represents a growing company that is capably meeting the challenge of technological changes and strong competitive pressures.

The Publisher

troduction

Two years ago I was approached by your publisher to ite the initial so-called "business" editorial for the first ition of the *MICROWAVE JOURNAL*. I am not ite sure how I happened to be selected, but I suspect e motive involved the elements of our name "Microwave sociates" (it almost sounds like a magazine title), possible future advertising, the inverse square law of our mutual geographical location, and the bond of amateur radio. For my first editorial I glibly suggested (and used) the subject of the statistics of the microwave industry. This turned out to be dangerous since it required that, first, I define our industry and that, second, with very meager sources at my disposal, that I conjure up some

real numbers which I knew inevitable, as history unfolded, must be compared to the hard facts — witness the recent industry report published on the same 1958 period by the Department of Commerce.

Again I have received an invitation to write a guest editorial, but it is important to note that in the intervening two years, Mr. Bazzy, himself, has proved that his own business astuteness would more than qualify him to write future "business" editorials for anniversary issues. This time I will attempt to explore in a most superficial, qualitative way some of the factors that influence the growth or decline of some of the elements of our industry.

ONLY two years ago even the better security analysts were not too well informed on our industry. Within the past six months at least four reports have been prepared describing the microwave industry to the potential investor. These reports, plus the excellent performance of many listed microwave companies, have placed the microwave industry at a very high price earnings ratio and given us the "glamorous stock" appelation. Time will tell whether or not we deserve such a thing. This close, and, at present, good relationship with Wall Street has greatly assisted the recent expansion of the microwave industry by providing capital under favorable terms, given real leverage to stock option plans which have increased the density and fervor of top technical personnel within the smaller members of our industry, and in some cases has provided so-called "chinese money" used for mergers and acquisitions.

Not all of these effects are necessarily favorable either to the corporation or individual. One can easily be carried away by the high price of a given company's stock. It is still most desirable to judge a company on the traditional norms of performance since stock prices more often reflect what some buying or selling portion of the financial world thinks a company is going to do, rather than what it is doing. These predictions are often very wrong.

It is interesting to note that in the past decade within the growing microwave industry the product mix has changed violently over the period. Even more pertinent to this editorial, the people and companies who dominated the industry in 1950 have in many cases been replaced by a new cast of corporate and personal identities. This shift, while most reassuring to those on the way up, must certainly represent a caveat to those who think that they have arrived.

If one explores in some detail these changes, it is difficult to generate any universal rules leading to success or failure. The companies entering the decade seemed to fall into two broad categories: those with strong mechanical aptitudes and those with dominant strengths in electromagnetic microwave circuits. Only occasionally were the two requirements blended in a compatible manner. It would appear that the companies invading the microwave field with an emphasis on the purely mechanical domain have done less well than those emphasizing microwave techniques. However, there are several outstanding exceptions to this statement which are rapidly attempting to balance their management talents. On the other side of the coin there were several companies led by very capable theoretical personnel who have perhaps overemphasized such considerations to the extent that they have not been overly successful and have been absorbe into other operations. (Parenthetically it would see that although mergers may be great in some industrie the 1 + 1 = 3 platitude has not yet been realized i ours). One common denominator for success in the m crowave industry has been determination and enthusiasr

Perhaps at this point it would be well to pause, wit tongue in cheek, and question what are some of th criteria for success that might be applied to an allege microwave industrialist.

A synthesis of the utopian leader of our industry coul be that in the past decade has:

(1) Achieved a liquid net worth of over $1,000,00 for which he has invested not over $10,000 of h own money and given up not over 50% of th equity of his corporation.

(2) His company is listed on the New York Stoc Exchange and is selling at 60 times earnings.

(3) He is a Fellow of the IRE, listed in Who's Wh and spends a portion of his time as a visiting pr fessor at Harvard, MIT, Stanford, Cambridge Un versity or some similar university. A few hono ary degrees are also therapeutic.

(4) Membership in top secret summer study grou in Woods Hole or San Diego seems to be a unfailing sign of being IN.

(5) That all of this has been accomplished with n divorces, severe mental or physical illness eithe on his part or his immediate family. (Gelusil an a brief preventative maintenance session or tw with the family psychiatrist will not flunk the ca didate).

(6) His company is so constituted that if he left for year its growth rate and efficiency would be u impaired. (This would give him a terrible feelin of being dispensable and would probably jeopa dize him in category (5).

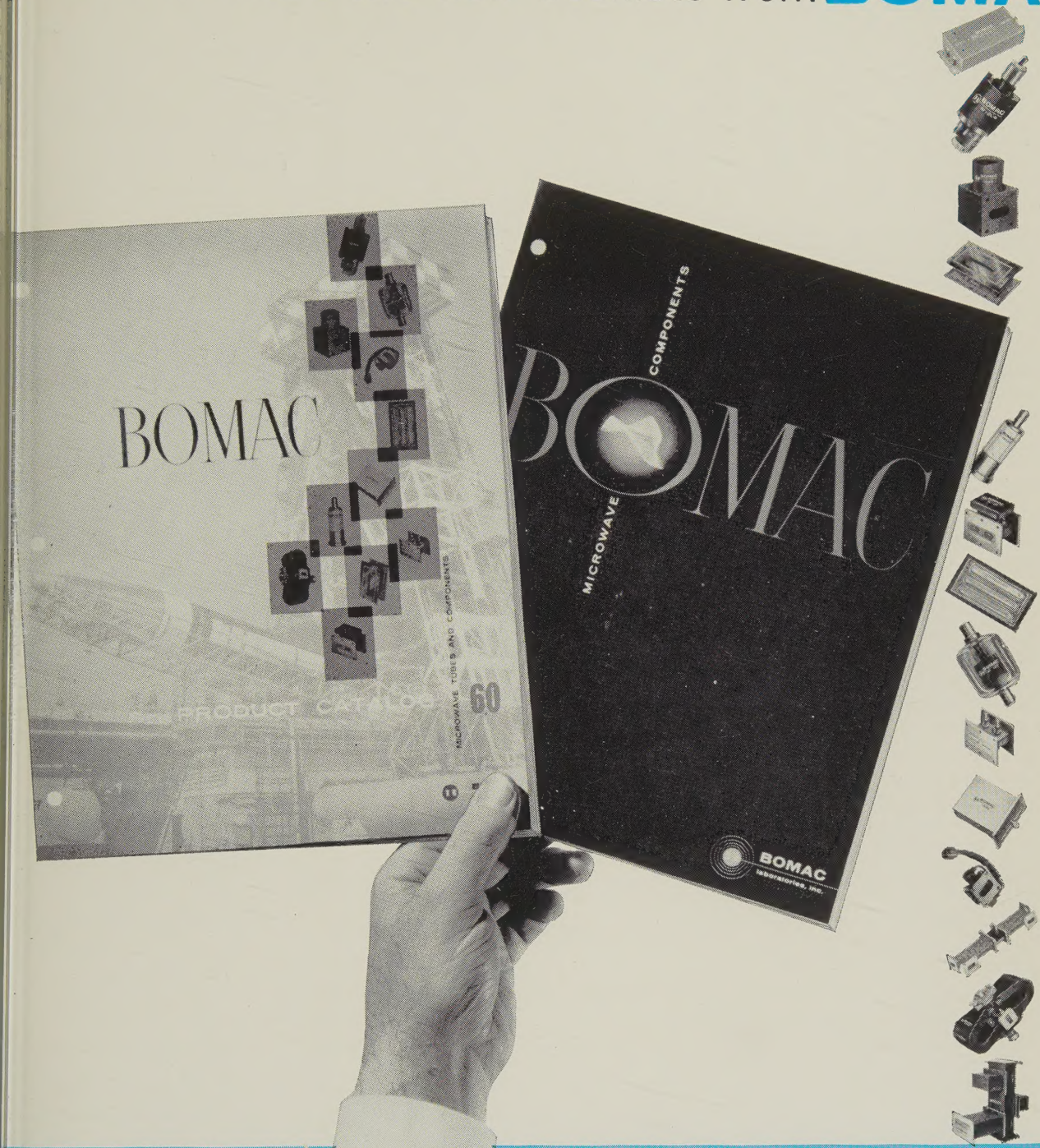
Obviously, this man doesn't exist, and if he did, h would probably be a pretty impossible character to liv with.

It is also axiomatic that what spells success to one ir dividual might not very well meet the requirements of second. In my synthesis I have adopted the broader vie and have perhaps disregarded some of the important pe sonal factors that drive men onward.

It is interesting to note that perhaps success in th microwave industry produces an asymptotic motivatio Can some of the "fat cats" produced in the markets c the past two years, continue to grow profitably with agilit or will the corrosive digestive juices of success leach ou the strong drives of our top hybrid scientist-businessme In most cases, I think the answer is "no"! I think th quest for the buck is not to be compared with the funda mental scientific interest that started these same peopl on their path.

Although the following is no substitute for an M.B.A from the Harvard Business School, I would recommen that much can be learned from buying one share each c all the microwave companies listed on the American an New York Stock Exchanges and over-the-counter ma kets, read the annual reports, prospectuses, and other com pany utterances; plot stock prices versus performance In two years time you will be an expert and can writ 1962's anniversary business editorial for this journal.

et the complete story on microwave tubes and components in these two new booklets from BOMAC



What's new in microwave? You'll find full information in these 2 new Bomac booklets. One is a complete product catalog in a new, more convenient format (tubes are listed first by band, then by type) to make it easier and quicker for you to find the tube you want. The second booklet gives you facts and figures on any of Bomac's new components and test equipment. Put together, they give you a complete, concise picture of what's new in microwave for 1960. Be sure to send for your copies today.

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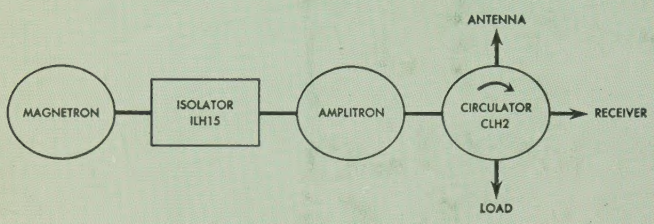
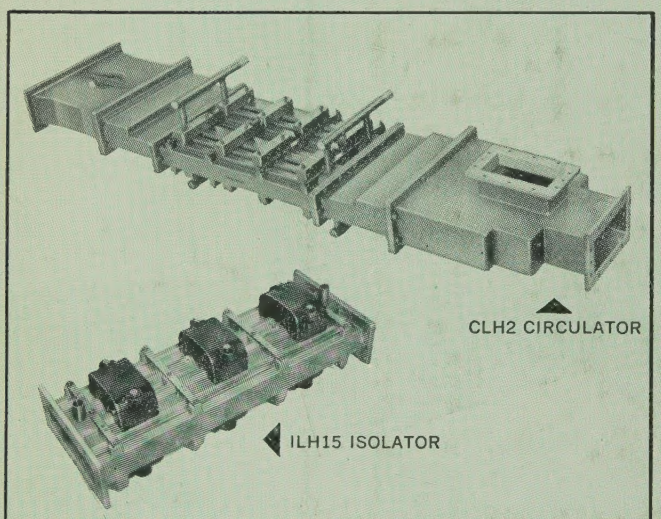
FERRITE DEVICES FOR HIGH-POWER RADAR





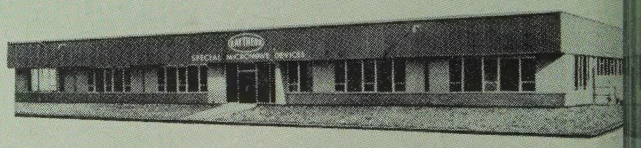
TYPICAL SPECIFICATIONS

	ILH15 ISOLATOR	CLH2 CIRCULATOR
Frequency range (mc)	1250-1350	1280-1350
Power, average	2.5 KW	5 KW
Power, peak	2 MW	6.5 MW
Isolation, min.	22db	26db
Isolation, max.	24db	32db
Insertion loss, min.	.7db	.65db
Insertion loss, max.	.9db	.8db
VSWR, min.	1.28	1.04
VSWR, max.	1.30	1.12
Weight, lbs.	60	140
Length, in.	22	69⅛
Flanges	½ ht. L-band	mates with UG418/U
Waveguide (liq. cooled)	½ ht. L-band	WR 650

RAYTHEON ISOLATORS AND CIRCULATORS IN IMPROVED L-BAND "FLIGHT TRACKER" SYSTEM THAT BOOSTS OUTPUT TO MORE THAN 5 MEGAWATTS

With an output of more than 5 megawatts at 1,280 to 1,350 mc., the improved FAA "Flight Tracker" radar system has *ten times* the power of its predecessor. In the microwave generator and amplifier circuits, Raytheon isolators and circulators help achieve this power level by providing the required broadband match between magnetron and Amplitron®...and between Amplitron and antenna. The isolator also aids in maintaining frequency stability during the 5 megawatt pulse peaks by acting as a buffer between magnetron and Amplitron.

The L-band ILH15 isolator and CLH2 circulator in the "Flight Tracker" are part of Raytheon's line of L-band devices with ratings from 1.5 to 10 kilowatts average and peak power capabilities as high as 6.5 megawatts.



On Massachusetts' Route 128 in the Waltham Industrial Park, Raytheon has recently opened the most modern facility devoted exclusively to microwave ferrite device and materials development, testing and production. To learn more about the work now underway at these new facilities, or for information on your particular microwave ferrite problem, **please write to the address below.**

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SPECIAL MICROWAVE DEVICE OPERATIONS
WALTHAM INDUSTRIAL PARK
WALTHAM 54, MASSACHUSETTS

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